THE

EMPORIUM

OF

ARTS AND SCIENCES.

VOL. III.] AUGUST, 1814. [No. II.

LEAD.

THE common ore, that which is almost exclusively worked, is the sulphuret of lead, or galena. This is usually a bluish ore in large plates or facets: when the facets are smaller, approaching to steel-grained, it is generally found to contain other metals, as silver, or antimony. It contains from 60 to 70 per cent. of lead.

It is most easily assayed in the dry way; most accurately in the moist way.

As silver in particular, and frequently also antimony is found combined with lead ore, it will be proper to give the assay and analysis of several kinds, which I shall do from Dr. Aikin, 1 Chem. Dict.

Assay and Analysis of the Ores.

The analysis of the ores of lead is upon the whole extremely simple. In general the moist way is the most accurate.

Before giving the individual processes the general methods may be mentioned whereby lead is separated from the other metals with which it is usually combined in the

different ores, and the data on which it may be estimated in analysis.

Lead is readily separated from silver by making a solution of both in nitric acid, and adding muriatic acid as long as any precipitate appears.

The silver falls down in the form of luna cornea, and with it a quantity of muriat of lead, and if the mixture stands some hours undisturbed, this latter salt also forms needled crystals on the surface of the luna cornea. All the silver falls down in this manner, but part only of the lead, and the muriat of lead is separated from the luna cornea by boiling water, 22 parts of which will dissolve 1 of muriat of lead, but not a particle of muriat of the silver. The solution of the muriat of lead is still more easily effected by digesting in dilute nitric acid, which dissolves it readily, but not the luna cornea.

Lead is separated from bismuth by dissolving both to saturation in nitric acid, either concentrated, or diluted with no more than a fourth of water, and then pouring the concentrated solution into a large quantity of water. The oxyd of bismuth then separates as a heavy white powder, and the lead remains dissolved. Some bismuth however remains, but to the solution may then be added a saturated solution of sulphat of soda, which will precipitate the lead only in the form of a white pulverulent sulphat of lead, the composition of which will be presently mentioned. But where all the bismuth is to be obtained for the purpose of analysis, and not merely to be separated from the lead, it is better after the bismuth has first precipitated, to add muriatic acid to the clear solution, which will throw down the silver, if there be any, and also some muriat of lead, mixed with some of the bismuth that remains in the solution, and which last if redissolved in nitric acid, will again be decomposed by water as before. The whole muriat of lead may then be dissolved in

water and nitric acid, and converted into a sulphat by means of sulphat of soda as before.

Lead is separated also from iron and copper by dissolving both in nitric or muriatic acid, and adding sulphat of soda to precipitate the lead. If the nitric acid be used, some of the oxyd of iron will first precipitate as a brown red ochre, which should be removed.

The same method will separate lead from tin, cobalt, and zinc.

The composition of the sulphat of lead artificially formed in these processes, has been given with some small variation by different chemists; Klaproth estimates it as follows.

100 parts of sulphat of lead, *dried at a low red heat*, are composed of 73.96 of oxyd of lead and 26.04 of sulphuric acid, and the above oxyd of lead is composed of 69.44 of metallic lead, and 4.52 of oxygen. This is not the only state of oxygenation of which lead is capable, but it is that in which, according to Klaproth, it is inferred to exist in all the native salts and oxyds of this metal hitherto analyzed.

It must be observed however, that this calculation gives a much lower state of oxygenation than is found by other experiments, as will be noticed presently, and the estimation of the quantity of metallic lead is made by other chemists, and even in other experiments of Professor Klaproth, to rise as high as about 71 per cent. Mr. Hatchett reckons it to be 70.9.

But where the muriat of lead is free from other admixture, the quantity of metal may be estimated without converting it into a sulphat, by the following data: 100 parts of lead dissolved in nitric acid, and decomposed by dropping in muriatic acid as long as any turbidness ensued, and evaporated to perfect dryness (but short of volatilization of any part of the combined muriatic acid) produced

133 of muriat of lead, and consequently 100 parts of dry muriat of lead indicate 75.2, nearly, of metallic lead, and (if oxygenated in the same degree as in the sulphat) 4.89 of oxygen, or 80.09 of oxyd of lead.

The muriat of lead may also be reduced by dissolving it in water and immersing a rod of iron, whereby the lead will be precipitated in the metallic state in fine lamellæ.

Some of the analyses of the individual lead ores may now be mentioned.

Vauquelin analyzed a galena from Cologne in the following way.

A quantity was roasted slowly and lost 12 per cent. of sulphur in the process. Another quantity was heated with very dilute nitric acid, which gave a smell of sulphurretted hydrogen, and dissolved all the metallic part. The undissolved residue heated to redness, parted with its sulphur, and 16.67 per cent. of silex was left. The nitric solution was then decomposed by sulphat of soda, and the sulphat of lead collected and weighed. The proportion of metal it contained (estimating 100 of the sulphat to be equivalent to 75.72 of metal) was 63.1 per cent. The liquor was then saturated with ammonia, which deposited 3.3 of oxyd of iron, and lastly carbonat of potash threw down 5 of carbonat of lime.

In the *dry way* the galena after roasting may be mixed with thrice its weight of black flux,* covered with salt, and melted, when a button of reduced lead will be found

* Black flux is made by deflagrating together in a red hot crucible equal weights of crude argol or tartar, and nitre. In a common way, roast an ounce of the powdered ore for two hours frequently stirring it: then add to it, of pounded green glass an equal weight, and of borax and black flux each also an equal weight, with 10 grains of lamp-black. If thrice the weight of black flux be used, the alkali will dissolve some of the lead. T. C.

at the bottom, which will also contain the silver and other metals if present.

The triple sulphuret of lead, antimony, and copper found in Cornwall, was thus analyzed by Mr. Hatchett.

Two hundred grains were put into a matrass with two ounces of muriatic acid, and heated, and nitric acid was added drop by drop, till the whole moderately effervesced. It was then gently heated for an hour, and a green solution was formed, on which floated a quantity of sulphur, which was collected, digested separately with a little muriatic acid, and then washed and dried. It weighed 34 grains, and afterwards burned away in a red hot earthen cup, without residue, and therefore was pure. The solution, with the muriatic acid in which the sulphur had been washed, was boiled, and then mixed with 6 pints of boiling distilled water, which it rendered instantly milky, and was filtered while hot, and the filter washed with more boiling water. The white precipitate left on the filter, when dried on a sand bath, weighed 63 grains, and was oxyd of antimony. The liquor with the washings deposited on cooling some crystallized muriat of lead. It was evaporated nearly to dryness, and a few drops of sulphuric acid added to the liquor left, to separate in the form of a sulphat, what little of the lead remained in solution. The residue was then redissolved in boiling water, and decomposed entirely by sulphat of soda, and the sulphat of lead thus produced, (added to the former portion) was washed and dried on a sand bath, and weighed 120.2 grains.

The liquor which was now bluish-green, was rendered of a deep blue by ammonia, and a small quantity of oxyd of iron separated, which when dried and heated with wax, became magnetic, and weighed 2.4 grains.

The liquor was then evaporated nearly to dryness, boiled with a strong lixivium of potash till nearly dry, and on

washing with water, some black oxyd of copper was left weighing 32 grains after thorough drying.

In the above analysis the metals are estimated as in their metallic state, this being the state in which they exist in the sulphurets, and hence, for the 63 grains of oxyd of antimony, 48.46 of the regulus are to be put down, and for the 120.2 of sulphat of lead, the author estimates 85.24 of metallic lead, which is in the proportion of 70.9 in 100.

The carbonat of lead was analyzed by Klaproth in the following way: 100 grains were dissolved in a mixture of 200 grains of nitric acid with 300 of water, and the loss of weight by the effervescence noted, which amounted to 16 grains, and was carbonic acid. The nitric solution was then diluted, and a cylinder of zinc immersed, which precipitated the lead in the metallic state in beautiful vegetations. This washed and dried, weighed 77 grains, equivalent to 82 of oxyd, as it is in this state that the lead exists in the ore. This proportion however, would give an increase of only 6.5 of oxygen upon 100 of lead.

That rare variety of lead ore, the compound carbonat and muriat of lead, has been analyzed both by Klaproth and Chenevix. By Klaproth, the following method was pursued: fifty grains of the ore were rubbed with 150 of very pure carbonat of potash, (previously freed from every muriat) and heated in a platina crucible to a moderate redness, then lixiviated and filtered. An oxyd of lead was left behind. The solution was slightly supersaturated with nitric acid and precipitated with nitrat of silver. The muriat of silver thus obtained weighed 27 grains, equal to more than 4 of concrete muriatic acid. Another quantity of the ore of 100 grains was then powdered and nitric acid affused, which produced an effervescence of carbonic acid. This solution gave with nitrated silver 55 grains of luna cornea, corresponding very closely in proportion with the former experiment, the acid of

which amounted to 8.5 grains. The lead was then precipitated by *caustic* potash and the oxyd thus procured weighed, after thorough drying, 85 1-2 grains, which is the state of oxygenation in which it is supposed to exist in the ore. In this case, therefore, 85.5 grains of oxyd of lead were combined with only 8.5 of muriatic acid which is far short of the saturating quantity, since in the artificial crystallized muriat of lead the proportion of acid amounts to 13 or 14 per cent. This deficient saturation therefore allows the presence of carbonic acid, which amounts to 6 grains, and completes the saturation of oxyd.

A similar ore was analyzed by Mr. Chenevix, nearly in the same way and with the same result. The ore was first dissolved in nitric acid, and the quantity of carbonic acid, amounting to 6 grains, estimated by the loss after effervescence. The solution was then neutralized by ammonia, and tried by different tests. As nitrate of lime gave no precipitate, the solution could not contain either the arsenic or molybdic or phosphoric acids, and as nitrat of barytes gave none, the absence of sulphuric acid was proved.

Nitrat of silver was then added and a copious precipitate ensued, and the luna cornea weighed after drying 48 grains, which Mr. C. estimates as equivalent to 8 of muriatic acid. The composition of the ore is thus stated: 6 grains of carbonic acid saturate 34 of oxyd of lead, and 8 of muriatic acid saturate 51 of oxyd of lead, and the acids may be supposed to be in the state of perfect saturation, consequently the ore is composed of 59 muriat of lead and 40 of carbonat of lead; or of 14 of acid and 85 of oxyd.

The Anglesea sulphat of lead was thus analyzed by Klaproth: 100 grains were first ignited moderately and lost two grains, which were water of crystallization. The remainder was mixed with 400 grains of carbonated pot-

ash, and kept for some time in a red heat in a platina crucible, which gave a reddish-yellow hardened mass. This, digested with water, was all dissolved except the oxyd of lead separated in the previous process, amounting to 72 grains, after strong drying. This oxyd was redissolved in nitric acid, and deposited thereby one grain of oxyd of iron. The solution was then decomposed by zinc, and yielded 66.5 grains of metallic lead. The alkaline fluid formed by the washing of the contents of the crucible, after ignition, was then saturated with nitric acid and acetate of barytes added as long as any sulphat of barytes was precipitated. This amounted to 73 grains, equal to 24.8 of concrete sulphuric acid on the estimation that 100 parts (after ignition) contain 34 of acid. The iron in this ore appears merely casual.

The phosphated lead ores have been also examined by the same eminent Chemist with much attention. The composition of all the varieties is very uniform, all consisting of phosphoric acid and oxyd of lead, together with muriatic acid, the quantity of which varies very little. It is a distinguishing and singular property of the phosphat of lead, that when melted into a round bubble under the blow-pipe it assumes a regular polygonal garnet-shaped form on the moment of solidifying by cooling.

The green phosphat was thus analyzed: after some imperfect attempts at reduction in the dry way, 100 grains of the ore were dissolved in hot nitric acid leaving no residue. Nitrat of silver then gave a precipitate of 11 grains of luna cornea, the muriatic acid of which amounted to 1.7 grains. Sulphuric acid was then added to the warmed solution, by which sulphat of lead was precipitated, weighing after ignition 106 grains, equal to 73.61 of metallic lead or 78.4 of the oxyd. The liquor was then freed from the excess of sulphuric acid by nitrat of barytes, it was then nearly saturated with ammonia, and ace-

tite of lead added. The phosphoric acid in the solution, was then precipitated in the form of phosphat of lead, weighing, after ignition, 82 grains, of which the mere acid amounts to 18.37 grains. The rest of the solution was then mixed with a little muriatic acid, inspissiated by evaporation, and alcohol added to redissolve the muriat of iron then formed, if any, from which by the addition of prussiat of potash there was obtained an extremely small blue precipitate, indicating no more than about .1 of a grain of oxyd of iron.

In another experiment the phosphoric acid, instead of being engaged with lead, was saturated partly by soda, partly by ammonia, and by due evaporation and cooling, crystals of the microcosmic salt, or the phosphat of soda and ammonia were obtained. The other varieties of this phosphat were analyzed in the same way.

With regard to the analysis of the molybdat of lead the reader is referred to the article *Molybdena* and to *Chrome*, for the Chromat of lead. Those ores in which lead is only a small part of the metallic contents will be described under the other metals as silver, bismuth, &c.

The compound of oxyd of arsenic, lead, and iron, examined by Lelievre, and Vauquelin, gave the following appearances: 100 parts roasted for half an hour, with a little suet added occasionally to favour the evaporation of the arsenic, lost 38, and became black and magnetical. The remaining 62 parts boiled in muriatic acid made a red solution, giving out much oxymuriatic acid gas, and crystallized muriat of lead was deposited. This solution evaporated, redissolved in water, and decomposed by sulphat of soda, gave 25 of sulphat of lead, equal to 20.2 of lead or 22 of the oxyd. The residue, saturated with ammonia, gave 39 parts of oxyd of iron.

The analysis of lead ores in the dry way is attended

with much more loss of the metallic contents, especially when alkaline fluxes are used, all of which act more or less on this oxyd.

Smelting and reduction of Lead Ores.

The only ore of lead that is wrought in the large way is galena, and the method of treating this is very simple, partly on account of the richness of the ore, and partly on account of the low price of the metal itself, which therefore will not admit of any but the most summary methods of bringing it into a marketable state.

The ore when first brought up from the mine is *dressed* by women and boys, who with a hand-hammer separate the greater part of the adhering impurities, consisting of blende, iron, pyrites, quartz, calcareous spar, &c. The residue being broken into pieces about the size of a hazle-nut, is washed from all adhering clay and dirt, and is then ready to be smelted. The furnace used for this purpose is the common reverberatory with a low arch. A ton or more of the ore is spread on the floor of the furnace, and by means of the flame from pit-coal it is quickly brought to a bright red heat. In this situation it is occasionally stirred with iron rakes to expose fresh surfaces to the action of the flame and facilitate the separation of the sulphur. In a short time the mass begins to acquire a pasty consistence; upon which the heat is lowered and the ore is kept at a dull red till the sulphur is nearly all got rid of; the fire being then increased the ore is brought to a state of perfect fusion, and visibly consists of two fluids; the lower is the metallic lead, the upper is a vitreous slag, still holding a considerable portion of lead but mixed with various impurities. In this state of the process the fire is damped and a few spadefuls of quicklime are thrown into the fluid mass; by this, the scoriæ are suddenly solidified, and are raked to the side of the furnace; the tap-hole is

then opened, and the lead runs into moulds placed to receive it, where it congeals into oblong masses called *pigs*, weighing about 60 pounds each. As soon as the lead has run out of the furnace, the tap-hole is closed, the scoriæ are replaced in the bed, and being quickly raised to a glowing red heat are soon melted; the greatest part of the lead that they contained by this means collects into a mass at the bottom; a little lime is thrown in as before, the scoriæ thus rendered solid are raked aside, and the lead which they covered is let off into a mould. This second scoriæ, though still holding from 5 to 8 per cent. of lead, is now removed from the furnace, and applied to no purpose but that of mending roads, the expence of separating the last portions of metal being more than the value of the produce.

The lead of the first running is the best; that procured from the scoriæ being sensibly harder, and less malleable on account of the iron that it contains.

It is a matter of doubt among the most intelligent smelters whether there is any advantage in retaining the carbonat of lead, with which the galena is very often mixed in considerable proportion. On the one hand it is certain that it contains a large quantity of metal, and in assays is very easily reducible; but on the other hand, when treated in the reverberatory, it vitrifies almost at the first impression of the heat, and being a very active flux it is apt to bring the whole into fusion while much sulphur still remains unsublimed; hence the amount of scoriæ is prodigiously increased, and with it the trouble of the smelters, while the produce of lead is very little augmented. [2 *Aikin*, 14.

The following practical remarks of the Bishop of Landaff, are well worth attention.

It is not fifty years since the *blast* or *hearth* furnace, was the only one in use for smelting lead ore in *Derby-*

shire. In this furnace, ore and charcoal, or ore and what they call white coal, which is wood dried but not charred, being placed in alternate layers, upon a hearth properly constructed, the fire is raised by the blast of a bellows, moved by a water wheel; the ore is soon smelted by the violence of the fire, and the lead as it is produced trickles down a proper channel, into a place contrived for its reception. There are not at present, I believe, above one or two of these *ore hearths* in the whole county of Derby; this kind of furnace, however, is not likely to go entirely out of use, since it is frequently applied to the extracting lead from the *slag* which is produced either at the *ore hearth*, or the *cupola* furnace, and it is then called a *slag hearth;* and the lead thus obtained is called *slag lead:* the fire in a slag hearth is made of the cinder of pitcoal instead of charcoal of wood.

The furnace called a *cupol* or *cupola*, in which ores are smelted by the flame of pitcoal, is said to have been invented about the year 1798, by a physician named *Wright*, though Beccher may, perhaps, be thought to have a prior claim to its invention or introduction from Germany. But whoever was the first inventor of the cupola, it is now in general use, not only in Derbyshire and other counties, for the smelting of ores of lead, but both at home and abroad, where it is called the English furnace, for the smelting of copper ores. This furnace is so contrived, that the ore is melted, not by coming into immediate contact with the fuel, but by the reverberation of the flame upon it. The bottom of the furnace on which the lead ore is placed, is somewhat concave, shelving from the sides towards the middle; its roof is low and arched, resembling the roof of a baker's oven; the fire is placed at one end of the furnace, upon an iron grate, to the bottom of which the air has free access; at the other end opposite to the fire-place, is a high perpendicular chimney; the

direction of the flame, when all the apertures in the sides of the furnace are closed up, is necessarily determined, by the stream of air which enters at the grate, towards the chimney, and in tending thither it strikes upon the roof of the furnace, and being reverberated from thence upon the ore, it soon melts it.

It is not always an easy matter to meet with a current of water sufficient to move the bellows required in smelting on an hearth furnace; and to carry the ore from the mine where it is dug to a considerable distance to be smelted, is attended with great expence; this expence is saved by smelting in the cupola furnace, which not requiring the use of bellows, may be constructed any where. Wood is very scarce in every mining county in England; and though pitcoal costs ten or twelve shillings a ton in Derbyshire, (1787) yet they can smelt a definite quantity of ore in the cupola, at a far less expence by means of pitcoal, than of wood.—The flame which plays upon the surface of the ore and smelts it in a cupola furnace, is not driven against it with much violence; by this means small particles of ore, called *belland*, may be smelted in a cupola furnace with great convenience, which would be driven away, if exposed to the fierce blast of a pair of bellows in a hearth furnace. These are some of the advantages attending the use of a cupola in preference to a hearth furnace; and to these may be added one superior to all the rest,—the preservation of the workmen's lives; the noxious particles of lead are carried up the chimney in a cupola, whilst they are driven in the face of the hearth smelter at every blast of the bellows.*

They generally put into the cupola furnace a ton of ore, previously beat small and properly dressed, at one time;

* In the neighbourhood also of blast furnaces, the chimney is lined, and the adjacent ground covered with the white oxyd of lead which is lost to the smelter. T. C.

this quantity they call a *charge*; if the ore is very poor in lead, they put in somewhat more, and they work off three charges of ore in every twenty-four hours. In about six hours from the time of charging, the ore becomes as fluid as milk. Before the ore becomes fluid, and even whilst it continues in a state of fusion, a considerable portion of its weight is carried off through the chimney; what remains in the furnace consists of two different substances,—of the lead, for the obtaining of which the process was commenced,—and of the *slag* or *scoriæ*. The proportion between these parts is not always the same, even in the same kind of ore; it depending much upon the management of the fire. The lead, being heavier than the slag, sinks through it as it is formed, and settles into the concavity of the bottom of the furnace. The pure slag, according to the idea here given, is that part of the ore of lead which is neither driven off by the heat of the furnace, nor changed into lead. In order to obtain the lead free from the slag which swims over it, the smelters usually throw in about a bushel of lime; not, as is usually supposed, in order to contribute towards the more perfect fusion of the ore, but to dry up the slag which floats upon the surface of the lead, and which, being as liquid as lead, might otherwise flow out along with it. The slag being thus thickened by an admixture of lime, is raked up towards the sides of the furnace, and the lead is left at the bottom. There is a hole in one of the sides of the furnace, which is properly stopped during the smelting of the ore; when the slag is raked off, this hole is opened, and being situated lower than the lead in the furnace, the lead gushes through it into an iron pot placed contiguous to the side of the furnace; from this pot it is ladled into iron moulds, each containing what they call a pig of lead; the pigs, when cold, being ordinarily stamped with the maker's name, are sold under the name of

ore lead. After the lead has all flowed out of the furnace, they stop up the tap-hole, and drawing down the slag and lime into the middle of the furnace, they raise the fire till the mixture of slag and lime, which they simply term slag, is rendered very liquid; upon this liquid mass, they throw another quantity of lime to dry it up, as in the former part of the process. This second mixture of slag and lime is then raked out of the furnace, and the small portion of lead separated from the fusion of the first, generally to the amount of twenty or thirty pounds, being let out of the furnace, a new charge of ore is put in, and the operation re-commenced. In order to spare the lime, and the expence of fuel attending the fluxing of the mixture of lime and slag, they have in some furnaces lately contrived a hole, through which they suffer the main part of the liquid slag to flow out, before they tap the furnace for the lead; upon the little remaining slag they throw a small portion of lime, and draw the mixture out of the furnace without smelting it. This kind of furnace they have nicknamed a *Maccaroni.*

The process of smelting here described, appears to be defective in some points, which I will take the liberty to mention, and at the same time suggest the means of improvement; without, however, presuming to say, how far it may be expedient to adopt the proposed alterations; being sensible that what may appear very feasible in theory, or may even answer in small assays, may not be practicable in large works.

The first alteration which I would propose to the consideration of the lead smelters, is to substitute an horizontal chimney of two or three hundred yards in length, in the place of the perpendicular one now in use. In the preceding Essay, which was first published in 1778, mention is made of the probability of saving a large quantity of sublimed lead, by making the smoke which rises from

the ore pass through a horizontal chimney, with various windings to condense the vapour. I have since conversed with some of the principal lead smelters in *Derbyshire*, and find that I had over-rated the quantity of this sublimed lead; the weight of the *scoriæ* from a ton of ore, amounting to more than I had supposed; they were all of them, however, of opinion, that the plan I had proposed for saving the sublimate, was a very rational one. But so difficult is it to wean artists from their ancient ways of operating, that I question very much whether any of them would ever have adopted the plan they approved, if an horizontal chimney, which was built a little time ago in *Middleton dale*, for a quite different purpose, had not given them a full proof of the practicability of saving the sublimate of lead, which was lost in the ordinary method of smelting. This chimney was built on the side of an hill to prevent some adjoining pastures from being injured by the smoke of the furnace. It not only answers that end, but it is found also to collect considerable quantities of the lead, which is sublimed during the smelting of the ore; this sublimed lead is of a whitish cast; and is sold to the painters at ten or twelve pounds a ton; it might perhaps be converted into red lead with still more profit.

A second circumstance to be attended to in the smelting of lead ore, is the saving the sulphur contained in it. The pure lead ore of Derbyshire contains between an eighth and a ninth part of its weight of sulphur; but as the ore which is smelted is never pure, being mixed with particles of *spar*, *cawk*, *limestone*, *brazil*, and other substances, which the miners call *deads* we shall be high enough in our supposition, if we say that the ordinary ore contains a tenth of its weight of sulphur; it may not, probably, contain so much, but even a twelfth part, could it be collected at a small expence, would be an object of great impartance to the smelter. In the common method

of smelting lead ore there is no appearance of the sulphur it contains, it is consumed by the flame of the furnace, as soon as it is separated from the ore ; an attentive observer may, indeed, by looking into the furnace, distinguish a diversity in the colour of the flame, at different periods of the process ; during the first three or four hours after the ore is put into the furnace, the flame has a bluish tint, proceeding no doubt from the sulphur which, in being sublimed from the ore, is inflamed: after all the sulphur is separated from the ore, the flame has a whitish cast, and then, and not before, the fire may be raised for finishing the operation; for if the fire be made strong before the sulphur be dispersed, the quantity of lead is less, probably, for two reasons; the sulphur unites itself in part to the lead which is formed, and by this union becomes inseparable from it; for the sulphur cannot without much difficulty be separated from an artificial mixture of lead and sulphur, when the two ingredients have been fused together.—2. The sulphur, whilst it continues united to the lead in the natural ore, renders the ore volatile, so that in a strong heat a great portion of it is driven off. Hence, very sulphureous ores should be roasted for a long time with a gentle heat, and in this proper management of the fire, principally consists the superiority of one smelter above another.

An old lead smelter informed me that he had often reduced a ton of ore to sixteen hundred weight by roasting it, but that he did not obtain more metal from it by a subsequent fusion, than if he had fluxed it without a previous roasting. This may be true of some sorts of ore, but it is not true of very sulphureous ores. Indeed the fire may be so regulated in a cupola furnace, as to make it answer the purpose of a roasting and a smelting furnace at the same time. I have seen much lead lost by smelting a ton of sulphureous ore in eight hours, which might

have been saved, if the fire had at first been kept so gentle as to have allowed twelve hours for finishing the operation.

Sulphur cannot be separated from lead ore in close vessels, and the lead ore melts with so small a degree of heat, that there may be more difficulty in procuring the sulphur from the ores of lead, than from those of copper or iron, however, I am far from thinking the matter impracticable, though I have not yet hit upon the method of doing it; and the following reflections may, perhaps, tend to supercede the necessity of collecting the sulphur in substance.

When it is said that the sulphur is consumed by the flame of the furnace as soon as it is separated from the ore, the reader will please to recollect, that sulphur consists of two parts,—of an inflammable part, by which it is rendered combustible,—and of an acid part, which is set at liberty, in the form of vapour, during the burning of the sulphur. Now this acid, though it may be driven out of the furnace in the form of a vapour, yet it is incapable of being thereby decomposed; it still continues to be an acid; and, could the vapour be condensed, might answer all the same purposes as the acid of vitriol; since all the acid of vitriol, now used in commerce, is actually procured from the burning of sulphur. That the fact, with respect to the acid not being decomposed, is as I have stated it, may be readily proved. The smoke which issues out of the chimney for some hours after each fresh charge of ore, has a suffocating smell, perfectly resembling the smell of burning brimstone; and if a wet cloth, or a wet hand, be held in it for a very short space of time, and afterwards applied to the tongue, a strong acid will be sensibly perceived. Various methods may be invented for condensing this acid vapour, and, probably, more commodious than the following one, which, however, I will just take

the liberty of mentioning, as, if it should not succeed, the trial will be attended with very little expence.

Supposing then an horizontal chimney to be built, let the end farthest from the fire be turned up by a tube of earthen ware, or otherwise, so that the sulphureous acid may issue out in a direction parallel to the flue of the chimney, and at the distance of about a foot and an half above it. Let a number of large globular vessels be made of either glass or lead, each of these globes must have two necks so as to be capable of being inserted into one another; let these vessels be placed on the flue of the chimney, the neck of the first being inserted into the tube through which we have supposed the sulphureous acid to issue, and the neck of the last being left open, for fear of injuring the draught of the furnace. Let each of these globular vessels contain a small quantity of water, then it is conceived, that the heat of the flue will raise the water into vapour, and that this watery vapour will be the means of condensing the sulphureous acid vapour, if not wholly, at least in such a degree as may render the undertaking profitable.* When the sulphur is all consumed, the draught of the furnace may be suffered to have its ordinary exit at the end of the horizontal chimney, by a very slight contrivance of a moveable damper. Since the first publication of the preceding Essay, I have seen an horizontal chimney at the copper works near Liverpool, where every thing I had said concerning the probability of saving sulphur by roasting lead ore, is verified with respect to copper ore; and I believe a patent has been granted to some individual for this mode of collecting sulphur. Sulphur might be obtained with equal facility from the *pyrites* which is found amongst coal, and

* The sulphur *may* be worth saving, but I greatly doubt if the vitriolic acid be. T. C.

this application of the pyrites might, probably, be more lucrative than the present one—making green vitriol.

A third circumstance, which requires the utmost care of the lead smelter, is the leaving as little lead as possible in the slag. Near every smelting-house there are thousands of tons of slag, which when properly assayed, are found to yield from one-eighth to one-tenth of their weight of lead; though no person has yet discovered a method of extracting so much from them when smelted in large quantities; and indeed the smelters are so little able to obtain all the lead contained in them, that in many places they never attempt to extract any part of it: in some places where they do attempt it, I have known the proprietor of the slag allow the smelters 20s. for every pig of lead they procured of the value of 38s. besides furnishing them with fuel: and yet the men employed in such an unwholesome business, seldom made above 7s. a week of their labour. This fusion of the slag of a cupola furnace is made, as has been mentioned, at a hearth furnace; the coal cinder, which they use as fuel, and the slag, are soon melted by the strong blast of the bellows into a black mass, which, when the fire is very strong, becomes a perfect glass; this black mass, even in its most liquid state, is very tenacious, and hinders many of the particles of lead from subsiding, and it being from time to time removed from the furnace, a considerable quantity of lead is left in it, and thereby lost. A principal part of the lead contained in the slag of the cupola furnace, is not, I apprehend, in the form of a metal, but in the form of a litharge or calcined lead: a portion of the lead, in being smelted from its ore, is calcined by the violence of the fire; this calcined lead is not only very vitrifiable of itself, but it helps to vitrify the spar which is mixed with the ore, and thus constitutes the liquid scoriæ; might it not be useful to throw a quantity of charcoal dust upon the liquid scoriæ

in the cupola furnace, in order that the calcined lead might be converted into lead, by uniting itself to the inflammable principle of the charcoal?*—Iron will not unite with lead, but it readily unites with sulphur, and, when added to a mixture of lead and sulphur, it will absorb the sulphur, leaving the lead in its metallic form; might it not be useful to flux sulphureous lead ores in conjunction with the scales or other refuse pieces of iron, or even with some sorts of iron ore?—The smelter's great care should be to extract as much lead as possible at the first operation of smelting the ore, and to leave the slag as poor as possible; but if he should still find either the slag of the cupola furnace, or that of the hearth furnace, containing much lead (as that even of the hearth furnace certainly does), he may, perhaps, find it worth his while to reduce the slag into a powder by a stamping mill, or by laying it in highways to be ground by the carts, or by some other contrivance, and then he may separate the stony part of the slag from the metallic, by washing the whole in water, inasmuch as the metallic part is far heavier than the other.

I estimated the weights of several pieces of slag, and found them to differ very much from each other; this difference is principally to be attributed to the different quantities of lead left in them.

Weight of a cubic foot of

	Avoir. oz.
Slag from a cupola furnace where no lime was used - - - -	3742
Black slag from a hearth furnace -	3652
Another piece - - - -	3612
Black slag from another hearth furnace—struck fire with steel -	3378
Black glass slag - - - -	3371.

[3 *Watson's Chem. Essays*, 272—298.

* This is on the Stahlian or phlogistic theory. T. C.

The following article on the smelting of lead from Dr. Rees's Cyclopædia contains also many remarks of practical consequence.

Reduction of the Ores, or smelting of Lead.

Two processes are employed for the smelting of lead, the one by means of a blast furnace, called an ore-hearth, and the other by means of a reverberatory furnace. The latter is used throughout Derbyshire and North Wales, and is undoubtedly the best, where coal is not very scarce. In the former of these methods the ore and the fuel are mixed together, and exposed to the blast. The heat dissipates the sulphuret,* the ore being the common sulphuret of lead or galena. A portion of the lead is oxydated, which facilitates the vitrification of the earthy parts of the ore, and of the fuel. These together constitute the slag or scoriæ. The metallic lead falls into the lower part of the hearth, and is defended from the oxygen of the blast by the scoriæ, which is fluid upon its surface. The liquid lead is let off from time to time, always retaining a portion for the scoriæ to float upon. When the whole of the lead is to be drawn off, the blast must be stopped, and some lime thrown upon the liquid scoriæ, which renders it concrete, while the lead, being still liquid, can be run off.

The reverberatory furnace employed for smelting lead is made on the same plan with those commonly used for puddling iron, differing in size, and a few other particulars. The fire is made at one end, and the flame plays over the hearth, entering an oblique chimney at the end, which terminates in a perpendicular one, of considerable height. The length of the hearth, from the place where the fire enters, to the chimney, is 11 feet; two feet of this length next the fire constitutes the throat of the furnace; the width of the same is four feet, and its depth

* Rather the sulphur.—T. C.

about six inches; the length of the fire-place is four feet, equal to the width of the throat; its width two feet, and depth three feet, from the grate up to the throat of the furnace. The rest of the hearth is a concave surface nine feet long, four and a half feet wide at the throat of the furnace, seven feet four inches wide at the distance of two feet from the throat, seven feet two inches in the middle of the hearth, five feet eleven inches at two feet distance from the chimney, and two feet ten where the flame enters the chimney at two apertures, each ten inches square. These apertures terminate in the oblique part of the chimney, the section of which is 16 inches square, which communicates with the main chimney, the section of which is twenty inches square, supposing a straight horizontal line, drawn from the lower plane of the throat of the chimney to the opposite side of the furnace; the lowest part of the concave hearth, which is in the middle of this cavity, is nineteen inches below this line, the roof of the furnace being seventeen inches above the same line: the rest of the hearth is conformably concave.

On each side of the furnace are three openings, each about ten inches square, provided with iron doors, to be removed as occasion may require. They are arranged at equal distances from each other, between the commencement of the hollow hearth and the entrance into the chimney. The lower part of these apertures is on a level with the horizontal line above alluded to, being for the purpose of stirring and raking the ore, &c. Besides the larger openings there are two small apertures, one below the large middle opening, and nearly on a level with the bottom of the furnace; the other under that next to the chimney, at some distance above the first aperture. The first is a tap-hole for the lead, and the second for the scoriæ. The ore is introduced by a vessel in the shape of a hopper, placed in the roof of the furnace.

Previous to the ore being smelted, it requires to be separated as much as possible from the earthy matter in which it is imbedded. Although galena, which is the ore used for smelting, is most frequently accompanied by sulphat of barytes, fluats and carbonat of lime, it is found to exist in crystallized distinct masses, and can be separated from it by mechanical means to a tolerable extent. The whole of the ore, with the earthy matter, is pounded to a certain degree with hammers; this is chiefly performed by women. In some places, however, it is broken down by passing it through iron rollers pressed together by great weights. After the ore has been thus reduced, the earthy matter is separated by washing. The powder to be washed is introduced into a sieve or riddle, and placed in a large tub full of water. By a certain motion given to the riddle, the lighter or earthy parts are thrown over the edge of the same, while the galena, by its greater specific gravity, is retained. This process requires great dexterity, which can be acquired by experience only. There are, however, some impurities which cannot be separated by this mechanical process, and are generally smelted with the ore. These are *blind** or *black-jack*, called by the smelter *mock* ore, pyrites, or sulphuret of iron, named *brazil* by the workmen. When the ore abounds much with these substances, the process of smelting is more difficult, and requires an extra assistance of flux to reduce it.

In the state above described, the ore is introduced at the hopper in the middle of the roof of the furnace, and spread upon the concave hearth, to expose it as much to the flame as possible, in order to facilitate the escape of the sulphur. This should be performed by a long continued heat which *is not violent*, in order that the sulphuret itself may not be volatilized, an effect which, more or less, always takes place. The moment the sulphur has left the lead, it be-

* Blende. Sulphuret of zinc.—T. C.

gins to combine with oxygen. The oxyd of lead, thus formed, combines with the earthy matter, which it renders so fusible as to become liquid upon the sulphur of the melted lead, and defends it from the future action of the oxygen. At this stage of the process the fire is raised to separate as quickly as possible the melted lead from the liquid scoriæ. The latter is now let off at the upper taphole, leaving a small portion still upon the lead to preserve it from the air. The fire at this period is lowered, and a quantity of coal-slack thrown in upon the melted mass. This serves as well to facilitate the cooling, and to cause the reduction of some oxyd of lead, which also tends to stiffen the melted scoriæ. This last effect, however, is not produced sufficiently, till a quantity of powdered lime is thrown into the furnace. By this treatment the remaining scoriæ becomes concrete, and is then broken to pieces and pushed to the opposite side by means of a rake, and taken out of the furnace at the different openings on the same side. The liquid lead is now let out, at its proper aperture, into a large iron pan, or cistern, from whence it is laded into moulds to cast into pigs. The furnace is now ready to be charged again. When the ore abounds with much impurity, the oxyd of lead is not sufficient to give the proper degree of liquidity to the scoriæ. In this case a certain quantity of fluat of lime is added, which has the property of forming a very fusible compound with sulphat of barytes, an ingredient very common in the ore.

This flux has been used from time immemorial for the same purpose, and has no doubt derived its name from its properties as a flux.

The concrete scoriæ, which is taken out of the furnace, is found to contain some lead, independent of that in the state of oxyd, and chemically combined. This is generally lodged in the cavities of the spongy mass. These

masses are taken to a kind of blast furnace, called a slag-hearth. By this second fusion of the scoriæ, the lead drops through the liquid mass into the lower part of the hearth, where it is not acted upon by the blast, and from thence is let off and cast into pigs. This lead is said to be of an inferior quality. Some ores of lead contain silver. The great affinity of lead for that metal is such, that the whole of it is found in the lead, from whence it is afterwards separated. [*Brewster's Cyclopædia.*

On the Smelting of Lead.

DEAR SIR—Most of the lead of commerce is obtained from that species of ore which is by mineralogists called *galena*, *potter's ore*, or sulphuret of lead. Indeed, it is the only species of lead ore which is found in sufficient quantities to be worth working.

There are many other species of lead ore met with occasionally; but these, occurring but seldom, are regarded as curiosities, and are generally carefully selected for the cabinet of the mineralogist, or as ornaments for the mantlepiece of the miner.

The ore, as it is first raised from the mine, is mixed with a considerable proportion of the matrix or gangue of the vein, from which it must be in great measure freed before it is fit for the operation of smelting.

For this purpose, the ore is delivered to the *dressers*, who either break it into small pieces with hand-hammers of a peculiar construction, which are called *buckers*, or it is passed between rollers worked by machinery, or under stampers. It then undergoes the operation of washing, to separate it from the lighter foreign matter, after which it is ready for the smelter.

Construction of the Ore Hearth.

The smelting of lead is performed differently in different districts. In most parts of the North, particularly in

Smelting of Lead.

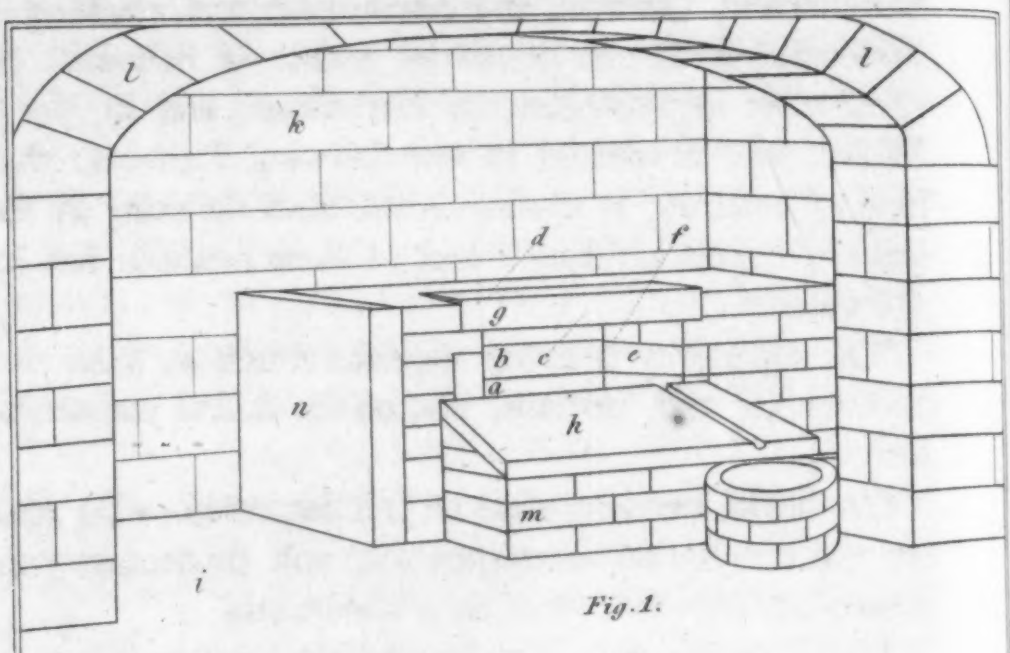


Fig. 1.

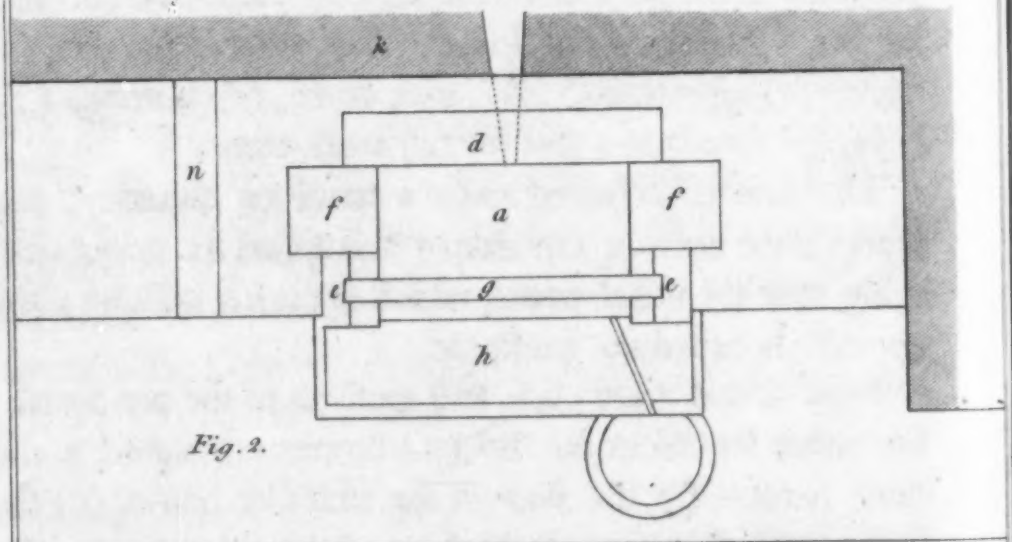


Fig. 2.

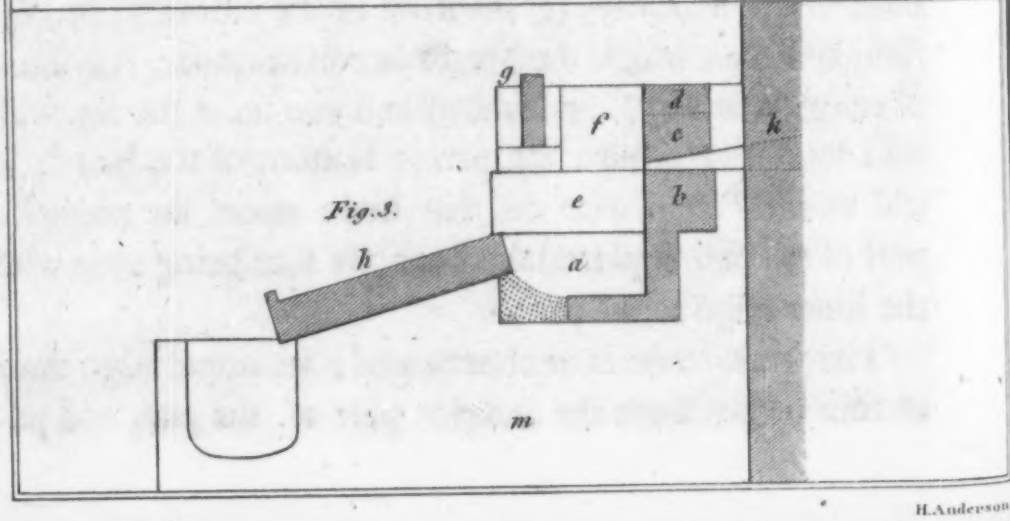


Fig. 3.

Cumberland, Durham, and Northumberland, smelting is performed in the ore hearth by means of bellows. In some parts of Yorkshire, in Derbyshire, and in North Wales, lead is smelted in reverberating furnaces: this kind of smelting is distinguished from the other by the name of cupola smelting: each of these methods has its advocates.

The superiority of either depends much on local circumstances, and, perhaps, also on the skill of the workmen.

Ore-hearth smelting shall be first described.—To render the description intelligible, it will be necessary to commence with a description of the hearth.

Fig. 1, of the plate, is a sketch of the hearth: it is constructed principally of pieces of cast iron, which are called generally iron stones or metal stones; each different casting has a distinguishing name: they are the (*a*) pan, (*b*) back, (*c*) pipe-stone, (*d*) spark-stone, (*e*) bearers, (*f*) keys, (*g*) fore-stone, and the (*h*) work-stone.

The hearth is erected under a spacious chimney, and nearly in the centre; one side of it is called the water-side, being near the water-wheel, which urges the bellows; the opposite is called the land-side.

Figs. 2 and 3 are plans and sections of the ore-hearth: the same letters in the different figures are placed to the same parts.—(*i*) the floor of the smelting-house, (*k*) the back of the chimney, (*l*) the front of the chimney, (*m*) the foundation on which the hearth is constructed: it is built of rough masonry, and levelled and run in at the top with thin mortar or grout; the pan or bottom of the hearth is laid steadily in mortar on this bed: upon the posterior part of the pan is placed the back, its face being even with the inner edge of the pan.

The work-stone is next arranged; its upper edge three or four inches from the anterior part of the pan, and pa-

rallel with the back; the bearers are placed on the sides of the pan, one end of each butting against the back, the other ends resting on the upper edge of the work-stone. Two thin pieces of stone, (about half an inch thick,) generally slaty sandstone, are laid on the back, and on these is placed the pipe-stone, the inner face of which overhangs the back near an inch. The keys are set on the bearers, their faces even with them; two pieces of brick are set on edge on the bearers, next to the keys, and on these, a few inches from the keys, rests the fore-stone; the spark-stone laid on the pipe-stone completes the hearth.

Before laying the foundation, a large flat stone (*n*) called the cheek-stone is fixed firmly in the ground, and determines the extent of the land-side of the hearth; the spaces between the water-side, the back of the chimney, and the cheek-stone are filled up with pieces of sandstone, bricks, or old iron-stones, and the interstices levelled up with dust. The fore-stone is wedged tight by its ends, generally against two old keys.

The space between the pan and the work-stone is filled with a mixture of bone and fern ashes well beaten in, and those between the keys and the ends of the fore-stone with stiff clay.

Care is taken in constructing the hearth to lay the bearers square, or at right angles with the back, and also to direct the blast immediately through the centre.

The hearth being completed, the operation of smelting commences with kindling the fire. The whole space between the fore-stone and back is filled with peats or chop-wood: an ignited peat or live coal being placed in the midst, the bellows are set to work: as soon as the combustion is sufficiently advanced, or that the whole are well on fire, one of the smelters (there are two to each hearth) throws a few shovels of half-smelted ore, (the remains of the last operation of smelting,) which is termed brouse,

on the top of the fire, gradually adding more as the contents of the hearth settle; he also adds a few small coals occasionally to keep up the combustion; when the whole of the brouse is thrown on the hearth, the other smelter watches-out; that is, with a long pointed crow-bar, called a gavel or gable-hook, he stirs up the whole of the brouse, and brings forward a great part of it upon the work-stone: this is effected by introducing the gable-hook into the hearth six different times, in the following order: he first forces it under the brouse a few inches on one side the centre, until the point touches the back; he then forces as low down as he can the end he holds in his hand; this lightens up the contents of the hearth, and as the bar is withdrawn, a part of the hot brouse comes forward on the work-stone; the gable-hook is then entered below the brouse, about the same distance from the centre, on the other side, where the same operation is performed: it is next introduced close to the side of the hearth; here the workman forces the end of the gable-hook from him, at the same time he presses it down, so as to bring the point of the bar into the middle of the hearth; this brings part of the brouse, which was next the side, into the middle, and what was in front, out on the work-stone. The gable-hook is again introduced in the same place, and the point raised close to the side, to remove any brouse that may adhere to the bearer or key. The same operation is performed at the other side, to remove the brouse from thence also. Whilst the watcher is performing his part, the man who supplied the hearth, and who is called the setter-on, thrusts his shovel down into the hearth, a little below the entrance of the blast, and forces the brouse sufficiently forward to allow him to place a peat or a handful of chop-wood horizontally before the orifice of the bellows: this he generally gets done nearly as soon as the other has finished watching, who changes his gable-hook for a sho-

vel; the setter-on comes to the front with his shovel, and they together throw the whole of the brouse again into the hearth, over the fore-stone, with a small quantity of coal as they see necessary, carefully separating the slags, which they throw into a corner, and breaking down the larger masses of brouse: when the whole is in the hearth, the setter-on goes again to the side, levels the top of the brouse, and covers it with fresh ore, laying this thickest against the spark-stone: the working of the hearth, after watching, is called setting-up. When a hearth is well set-up, and works properly, without an excess of coals or blast, and pretty free from slags, small reddish white flames issue from all parts of the breast, from below the fore-stone, nearly to the edge of the work-stone: these flames should not issue more than a few inches from the breast. The hearth does not continue long in this state; as the peat burns away, the blast is less equally distributed; it forces itself through more in some parts than in others; the covering at the top is perforated, or, perhaps, perfectly ignited, and the whole mass is condensed and settled in consequence of the evaporation of one part of the ore, and the separation of the metal; copious blueish flames issue from two or three parts of the hearth, as if occasioned by the combustion of some metal. The brouse must be again watched-out, a new peat put in, and more ore thrown on the top. The operations of watching and setting-up require to be repeated about every three minutes. After a few times setting-up, the metallic lead begins to flow down the channel of the work-stone, into a pot, where it is kept hot until collected in sufficient quantity to cast a pig.

It is necessary, for the easy management of the hearth, that a considerable quantity of fluid lead should remain in the bottom for the brouse to float on. The watcher, after throwing up the brouse, allows the lead to flow freely

down the gutter for a short time, and then prevents any more escaping, by lightly raising up the brouse against the gutter with the corner of his shovel.

Two men will smelt about six bings of good ore a day, and from these produce 24 pigs of lead, weighing 154lbs. each.

It is advisable to draw the hearth at the end of every twelve hours, in order that it may cool; for a cool hearth works pleasanter, and makes better produce than one which has been suffered to heat. The hearth should be drawn about two watchings after throwing on the last of the six bings of ore. As soon as the hearth is watched-out the last time, the action of the bellows is stopped, and the smelters draw out the whole of the hot brouse with their shovels, and throw it on the floor to cool, picking out such slags as they may observe; they also remove whatever adheres to the sides or back.

If the hearth has been properly attended, and a due proportion of fuel used, it will scarcely appear hotter in one part than another; and, if it has been working with a free ore, should not appear hotter than a very dull obscure red heat.

With a free ore, the hearth, when fresh set-up, works as before described, the blast finding its way equally through all parts of the breast. The brouse, when watched-out, is dry, and mostly in small pieces, the slags firm, and easily distinguished by their cavernous appearance and brighter colour, and the lead flows from the hearth scarcely red hot. Lead ore, which contains much silver or copper, or which has not been properly cleared from the gangue with which it is mixed in the vein, requires particular attention on the part of the smelter: instead of working dry and open, it becomes soft and pasty; the slag, instead of separating in firm pieces, is diffused through the whole like a half-melted scoria, and the least

inattention to the fire will set the whole contents of the hearth into a solid mass, or cause it to boil and flow down in a liquid state on the work-stone—the lead flows very hot, and the hearth appears hot and foul. The addition of lime is necessary to correct this defect in the ore, which combining with the fluid scoriæ, solidifies, and thus assists its collecting in masses: care should be taken not to add more lime than is absolutely necessary for the purpose intended, as all extraneous matter thrown in with the ore lessens the produce of lead.

The substances which are found to render the ores of lead refractory, when mixed with them, are cawk, (*sulphate of barytes,*) black jack, (*blende* or *sulphuret of zinc,*) sulphur, (*iron pyrites,*) and silver, or copper, when they are contained in the ore in larger proportions than usual.

I have always considered that these substances render an ore refractory by the extra quantity of sulphur they bring with them. I do not think the earth or metals alone would produce any visible effect in the smelting; and I am almost confirmed in this opinion, by repeatedly observing the effect produced by roasting the ore previous to smelting; it works more pleasantly, requires less lime and fuel, and gives a better produce.

The quality of the coals materially affects the working of the hearth and the produce of lead; those which are free from sulphur, and which leave but little residuum after combustion, are the best fitted for smelting.

The lead which is separated directly from the ore, is called ore lead, or common lead, to distinguish it from that which is the result of a subsequent process.

Slag-hearth Smelting.

The slags or scoriæ separated in the process of ore-hearth smelting, consist of the infusible part of the ore, the ashes of the coals, peats, &c. semi-vitrified and aggluti-

nated by a quantity of oxyd of lead produced by the action of the blast; they contain also particles of metallic lead dispersed through their substance, and not unfrequently unreduced ore.

These scoria, which are technically named *gray slags*, vary considerably in the quantity of lead they contain, but the poorest hold a sufficient quantity to pay the expense of smelting.

As it is necessary to bring these slags to a perfect fusion to separate the lead, a furnace capable of producing a more intense heat than the ore-hearth is requisite. The plate contains plans, sections, &c. of the slag hearth, in which the same letters are applied to the same parts in the different figures. Fig. 1 is a perspective view of the hearth; Fig. 2 a plan; and Fig. 3 a perpendicular section; (*a*) a cast-iron plate, which forms the bottom of the hearth: an old work-stone is generally used for this purpose; what it wants in dimensions is supplied by other old castings, refuse of the ore-hearth: the bottom is laid in fine dust which has been damped a little, and well rammed; on the bottom is placed the back (*b*) which is formed of three or four old bearers laid on each other; on the centre of the back is placed the tuyre, or as it is generally called the *tue-iron*. The pipe-stone (*c*) is bedded in tempered clay on the back; it is a block of freestone about 15 or 18 inches square, and 30 long, hollowed out on the underside to fit the tuyre. Two old bearers (*d d*) about 18 inches apart, and placed at right angles with the back, against which their ends butt, form the lower part of the sides; on these, two blocks of freestone (*e e*), about 15 by 18, and in length equal to the height of the pipe-stone, are placed on end; the front is built entirely with old castings, the lower one resting on the ends of the side bearers.

The spaces between the back of the chimney, the side and the cheek stone, are filled with old castings, bricks, or pieces of stone, and the joints filled up with dust or ashes; the space left between the bottom of the hearth and the lower front bearer is called the breast;—*(f)* is the sump or pot to contain the lead, as it flows from the hearth; the space between the breast and the sump is paved with old castings imbedded in dust, and the joints filled with thin mortar grout; near the sump is a mould for casting the lead into pigs.

The hearth is prepared for working, by slightly ramming into the bottom a quantity of coal ashes; the sump is also filled, and the space between it and the breast; the dotted part *(g g g)* fig. 3, represents the coal ashes: the fire is next lighted, and when the interior of the hearth has acquired a good red heat, the smelter throws on a few shovels full of gray slags (which have been previously broken to the size of an egg), and as the hearth settles, occasionally adds fuel or more slags as may be required: in a few minutes after charging with the slags a small perforation is made in the breast by passing a pointed iron rod through the ashes close to the bearer; the liquid scoriæ and lead flow through this opening down the inclined plane formed by the ashes; as they become hot the lead filters through them, and finds its way into the sump; the scoriæ from its viscidity remaining on the surface, from whence it is removed occasionally as it cools and becomes hard.

The slag hearth is continued working for 12 or 14 hours, the smelter adding materials occasionally as required, and judging of the proportion of fuel by the heat and appearance of the fluid scoria.

At the conclusion of the day's work the hearth is suffered to burn down as low as possible; and when the scoria ceases to flow, the bellows are stopped, the scoria on the

bed of ashes removed, and the lead which has collected in the sump is cast into pigs. Cool ashes are next spread over the hot bed, and the hearth drawn and cleared from what remains in it, and when moderately cooled, prepared with a bottom of ashes for a succeeding day's work.

The principal art in working a slag hearth is to keep a proper *noze*, and to have the hearth light and open in front, otherwise the blast does not work well and diffuse itself equally through all parts, but forces itself up behind and very soon destroys the pipe-stone.

The noze is a protuberance which surrounds the orifice, through which the blast passes; it is formed by the vitrified slags trickling down the pipe-stone, and cooled by the blast as it enters the hearth. With very fusible slags it is sometimes difficult to get a proper noze to form, and with refractory slags to keep it of a moderate size. With too large a protuberance, the hearth works most at front; with too small, chiefly at the back.

In general a noze may be prevented growing too large, by laying the fuel principally near the pipe-stone, and occasionally forcing in a pricker through the tuyre.

A noze may be enlarged by a contrary situation of the fuel, and throwing in close to the pipe-stone a few shovels of dust and ashes from the top of the hearth.

The fuel used at the slag hearth is coke.

The scoria, the refuse of the operation in the slag hearth, is called black slag; it contains a portion of metallic lead which is separated by stamping and washing.

The lead obtained by the slag hearth is hard and sonorous; it is of an inferior quality, and unfit for many of the purposes to which common lead is applied.

Cupola Smelting.

For the method of smelting lead by the cupola furnace as principally practised in Derbyshire, I refer to Watson's Chemical Essays; a more correct or interesting account cannot be given, (already inserted).—38 *Phil. Mag.* 371.

The process for refining Lead, as practised in England. In a letter from Mr. John Sadler.

WITH TWO ENGRAVINGS.*

MY dear Sir—Citizen Duhamel, in his Memoir on the refining of Lead in the large way, has given a sketch of the process used in England; if you think the following more detailed description will be acceptable to the readers of the Philosophical Journal, it is at your service.

The object of refining lead is not merely on account of the silver it contains, but to procure it as free as possible from the other metals with which it is usually alloyed, and to procure litharge. The silver is only an object, so far as it helps to pay the expense of refining.

The lead produced at the smelting hearths or furnaces in England is never perfectly pure; it is always alloyed with a portion of silver, and most commonly with one or most of the following metals; namely, zinc, antimony, copper, and arsenic; which render it unfit for some of the purposes to which lead is applied.

The operation of refining is founded on the facility with which lead is oxydated when exposed to heat in contact with atmospheric air, and the peculiar properties the oxyds of lead possess; being easily fused, and in that state oxydating and combining with most of the metals; gold, silver, and platina excepted.

* These will be given in the next number.

Refining Furnace.

Fig 1.

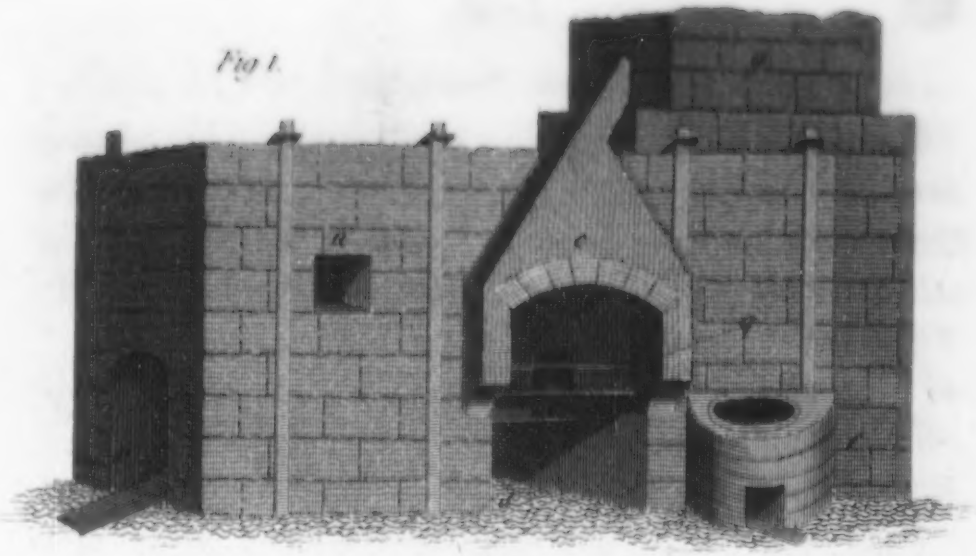


Fig 2.

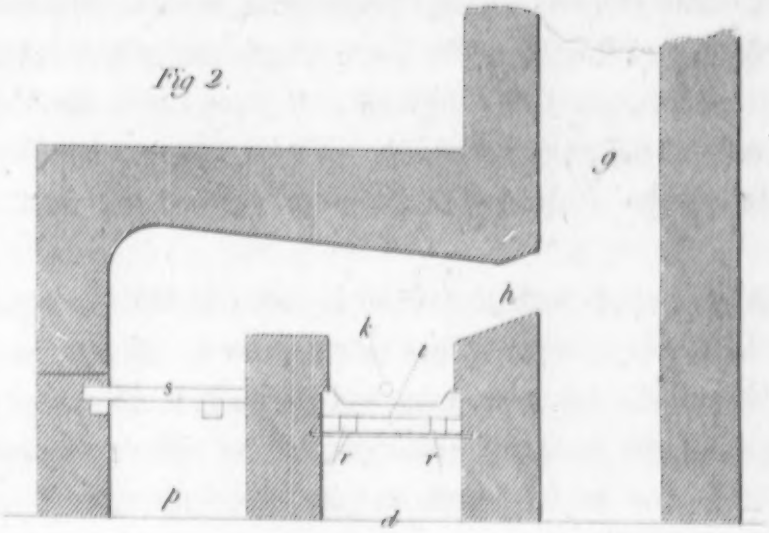
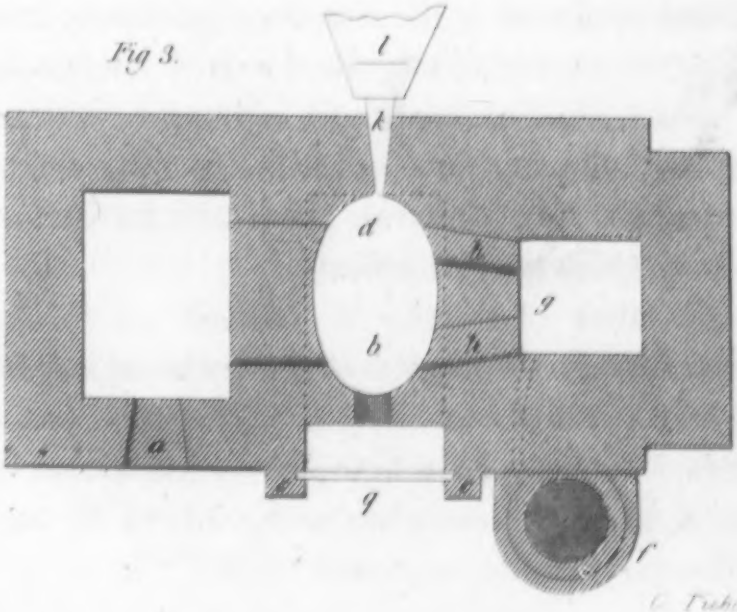


Fig 3.



C. Prichout.

Refining of Lead.

Fig. 1.

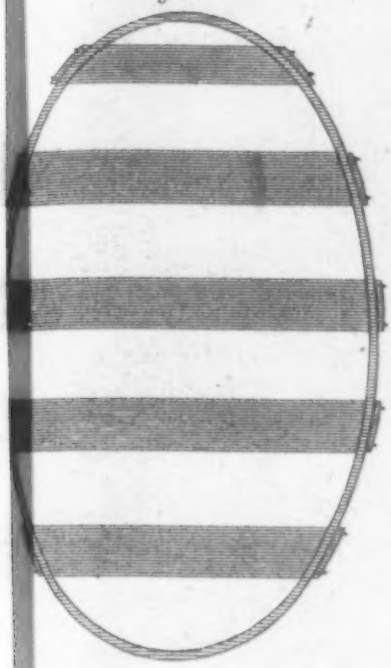


Fig. 2.

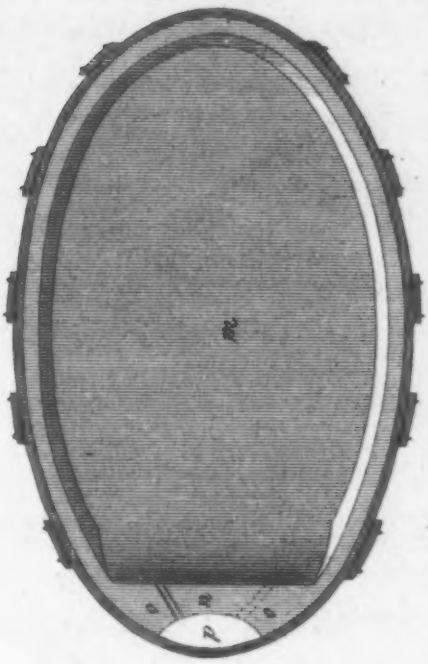
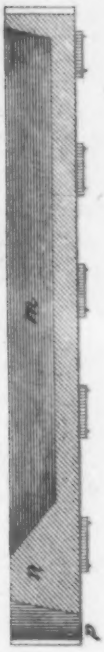
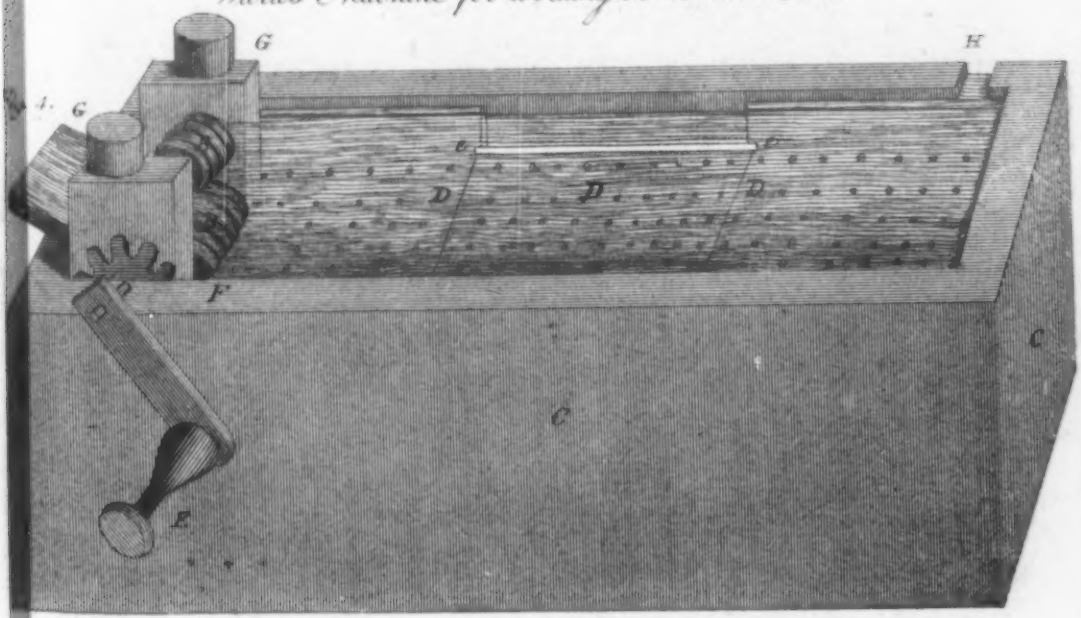


Fig. 3.



Wards Machine for working in White Lead.



H. Anderson sc.

The lead to be refined is exposed to the action of heat and air upon a *cupel* or *test*, composed of a mixture of bone and fern ashes, in a reverberatory furnace; the description of which, with the different manipulations, are as follows:

The refining furnace is composed of good solid masonry, bound together with iron bolts. It differs very little in its construction from the common reverberatory furnace, except the bottom, which is perforated to receive the test or cupel.

Fig. 1, plate I, of the refining furnace is a perspective view of the furnace with its iron work; *a* the teazing hole, *b* aperture by which the test is supplied with lead, *c* an arch or dome over the feeding hole, communicating with the furnace stack by a flue, *d* area or space where the test is taken in and out the furnace, *ee* two strong iron bars to support the test when in its place, *f* cast-iron pot set in masonry, the flue passing into the stack of the furnace, *g* the stack, *p* the ash pit, *q* an iron bar to slide the ladle on when feeding the test.

Fig. 2, a perpendicular section of the furnace showing the test *i*, supported in its place under the opening of the bottom of the furnace by the two wedges *rr*; *k* aperture for the nozzle of the bellows, *s* fire bar resting on the bearers.

Fig. 3, plan of the interior of the furnace; *l* part of the bellows, *hh* flues from the body of the furnace to the stack.

The same letters in the different plans are meant to denote the same parts, in the next plate.

Plate II, fig. 1, plan of the iron frame into which the mixture of bone and fern ashes is rammed to form the test. This frame is something larger than the elliptical hole in the bottom of the furnace.

Figs. 2 and 3, plan and section of the test; *m* the part which contains the lead to be refined, *n* breast of the test, *oo* small gutters or channels through which the litharge flows, *p* a semi-elliptical hole for the litharge to fall through from the gutters, upon the area of the refinery.

These drawings and references will be sufficient to make the description of the furnace, &c. clearly understood.

Of the Test or Cupel.

A good test is of the first importance in refining; the method of constructing one I shall endeavour to point out. Six parts of well burnt bone ashes and one part of good fern ashes are to be well mixed, sifted through a sieve, (the spaces in which are about one-eighth of an inch square,) and moistened to about the same degree the founders use their sand. The iron frame is to be laid on the floor and made steady, with wedges under its rim; about two inches in thickness of the ashes are to be equally spread over the bottom, and with an iron beater, such as used by the founders, equally rammed between the cross bars; the frame is to be again filled and rammed all over, beginning at the circumference and working spiral ways until finished in the centre, the filling and ramming to be repeated until the frame is completely full; an excavation to contain the lead is made as expressed in the plan, with a sharpe spade about five inches square, the edges dressed with a long bladed knife; a semi-elliptical hole, as at *p*, is to be cut through the breast. Having proceeded so far, the test is to be turned on its side and dressed from all superfluous ashes adhering to the bottom, taking care that none shall be left flush with the bottom of the frame or cross bars, otherwise in fixing the test to its situation at the bottom of the furnace it would be liable to be bulged.

Fixing the Test in its situation.

The rim of the test is now to be plastered with clay or moistened ashes, placed upon the supporting cross bars, and fixed with wedges firmly against the bottom of the furnace, the breast next to the feeding hole.

A gentle fire may now be lighted, and gradually increased until the test be red hot. When it ceases to emit steam from the under side it is sufficiently dry.

Lead previously melted in the iron pot *f* is ladled into the test until the hollow part be nearly filled, the operator closes the feeding aperture, and increases the heat of the furnace until the surface of the lead is well covered with litharge; he then removes the door from the feeding hole, and with an iron rod, which has one end bent down at right angles about three inches, and made flat or chissel-shaped, scrapes the small gutter or channel *o* until the litharge just flows into it, the blast from a pair of double bellows is then directed from the back part over the surface of the test, the litharge is urged forward, and flows from the gutter upon the floor of the refinery; the operation now goes forward, gradually adding lead as the escape of litharge makes necessary, until the gutter is so worn down that the test does not contain more than an inch in depth of lead, the blast is then taken off, the gutter filled up with moistened ashes, and a fresh one made on the other side the brest; the test is again filled, though not so full as at first, and the operation carried on until this gutter also is worn down and the test contain from about fifty to seventy pounds of alloy. This quantity is run into an iron pot, and set by until a sufficient number of pieces have been collected to make it worth while to take off a plate of pure silver from them.

The quantity of alloy left in the working off each test must depend in a great measure upon the quantity of silver it by estimation is supposed to contain. A sufficient

quantity of lead should always be left in the alloy to make it fuse easily in the iron pot.

When the test is removed from the furnace and broken up, the litharge will be found to have penetrated to an inconsiderable but equal depth in the ashes; that part not impregnated with litharge may be pulverised, mixed with fresh ashes, and again used for another test.

The operation of taking off the silver pure, differs in no respect from the foregoing, only more care is observed in the working, not to suffer the escape of any metallic particles with the litharge, as that would occasion considerable waste of silver. As the process advances, and the proportion of silver to lead increases, the litharge assumes a darker colour, a greater heat becomes necessary, and at last the brightening takes place; the interior of the furnace, which during the whole of the process had been very obscure and misty, clears up. When the operator observes the surface of the silver to be free from litharge, he removes the blast of the bellows, and suffers the furnace to cool gradually; as the silver cools many protuberances arise on the surface, and fluid silver is ejected from them with considerable force, which falling again on the plate spots it very fantastically with small globules.

The latter portions of litharge bring over a considerable quantity of silver with them; this is generally reduced by itself and again refined.

The litharge as it falls upon the floor of the refinery is occasionally removed; it is in clots at first, but after a short time as it cools it falls for the most part like slacked lime, and appears in the brilliant scales it is met with in commerce: if it is intended as an article for sale, nothing more is necessary than to sift it from the clots which have not fallen and pack it in barrels.

If, on the contrary, it is intended to be manufactured into pure lead, it is placed in a reverberatory furnace,

mixed with clean small-coal, and exposed to a heat just sufficient to fuse the litharge. The metal as it is reduced flows through an aperture into an iron pot, and is cast into pigs for sale. During the reducing, care is taken to keep the whole surface of the litharge in the furnace covered with small-coal.

In some smelt works, instead of a reverberatory furnace for reducing, a blast furnace is made use of, on account of the greater produce, but the lead so reduced is never so pure as that made in the wind furnace. The oxyds of the metals, which require a greater heat to reduce than the lead, are in the blast furnace generally reduced with it.

The volatile oxyds, as zinc, antimony, and arsenic, are mostly carried off by evaporation during refining; a considerable portion of the oxyd of lead itself is carried off by evaporation, making the interior of the furnace so misty and obscure, that a person unused to refining cannot see more than a few inches into it.

A considerable portion of these oxyds are driven by the blast of the bellows through the feeding aperture, and would be dissipated in the refining-house, to the great injury of the workmen's healths; to prevent their ill effects the arch or dome over the feeding hole is erected to carry the fume into the stack of the furnace.

15 *Nicholson*, 1.

PROPERTIES of the metal LEAD. Lead obtained free from any other metallic mixture, (as by precipitating nitrat or acetat of lead by zinc) is when recently melted of a bright bluish-white colour, which soon tarnishes on exposure to air: but when once tarnished, lasts a long time exposed to the weather, for it does not decompose water as iron and copper do. It is the softest of the com-

mon metals. Its specific gravity is 11,35, which is not encreased by hammering. It is very malleable, but not very ductile. A wire of $\frac{1}{16}$ of an inch diameter supports only 18,4 lbs. its point of fusion is 612°. It evaporates in the common blast-heat of the hearth furnace. It combines with oxygen slowly, by means of heat. The oxyds appear to me to be, 1st, The greyish black dust that first appears on the surface of the melted lead. 2dly, The yellow massicot, which also is first of a dirty yellow and then of a greenish yellow, before it comes to be of a full yellow colour; indicating, as I conjecture, various states of oxydation. This yellow oxyd is massicot, to which red lead also may be reduced, by driving off a portion of its oxygen; though it is usually made, in the stage of the process that precedes the red lead. It is the oxyd of lead, usually supposed to be combined with acids, from which it may be precipitated by pure alkalies, as a white hydrated oxyd, from which the water may be expelled by strong heat. This white hydrated oxyd, like massicot, contains about 7 per cent. of oxygen. Dr. Thompson supposes that litharge is this oxyd of lead, mixed with a little carbonic acid obtained from the carbonaceous matter burnt in the refining furnaces, where litharge is made: but as yet, I hold all this to be probable conjecture only. We do not yet know the precise state of oxygenated lead that constitutes litharge. 3dly, Red lead, which contains from 10 to 11 per cent. of oxygen. 4thly, The brown, puce-coloured (flea-coloured) oxyd, containing from 13 to 14 per cent. of oxygen.

The puce-coloured or brown oxyd, is only made by the experimental chemist, by digesting nitric acid on red lead. The preparations of commerce among the oxyds, are white lead, massicot, litharge, red lead.

White Lead. This may be prepared several ways, viz:

1st, By corroding sheet lead with the fumes of vinegar, evaporated by the warmth of a hot bed of dung. This is the common process in this country.

2dly, By using for the same purpose, tanner's bark instead of dung, as the hot-house gardeners of Europe now do.

3dly, By exposing the vinegar pots to the same degree of heat excited by burning common fuel. This would be a much cleaner way of working; and in such a coal-country as Pittsburgh, I should think it would be full as cheap. The common heat of a stove-room, as used in England for converting cyder into vinegar, would answer very well as I think; and if not strong enough could easily be encreased.

4thly, By precipitating nitrat or acetat of lead by carbonated alkali. This makes a very white lead, but it does not absorb so much oil, or retain its colour so well, as white lead made in a common way.

5thly, By decomposing some of the neutral alkaline salts, as the muriats of potash and soda. I do not know whether the sulphats of potash and soda and the nitrats of the same alkalies have been used. Or whether, the muriats, sulphats, or nitrats of lime and magnesia would answer the purpose. The principle is the same, but there is full room for very important and valuable experiments; which probably will be the subject of a dozen patent rights; for in this country, if a man can contrive to eat his green peas with a four-pronged fork instead of a broad-pointed knife, he applies for a patent to secure the invention. For this mode of making white lead, Lord Dundonald has already obtained a patent. I greatly doubt whether he was entitled to it: for the process is very nearly that of Turner's mineral yellow.

I proceed then, to give an account of the common method of making white lead. Premising

1st. That it is necessary to set up the manufacture where good water is to be had in plenty: water containing hydrogenous, sulphureous or carbonaceous gas or salts, would spoil the colour.

2dly, It is desirable that fuel should be cheap, though this is not necessary: and that horse dung or bark should be of easy purchase.

3dly, There must be room and space for the manufacture. The person undertaking it in the common way, will need, at least, the following buildings:

A brewhouse for brewing vinegar from damaged grain.

A room for casting the lead into sheets; and for rolling it into spirals.

A smelting room, for recasting the refuse lead into blue lead again. These two rooms may be in one.

The casting room, the rolling-up room, and the smelting room should be contiguous, and may open into each other. The smelting room must be furnished with a fire place and chimney, and have a strong cast iron pan set in a brickwork furnace, to melt the lead. The rolling-up room should have a bench under the windows from one end to the other. All the rooms but the smelting room may be warmed by stoves.

A room for corroding the lead with vinegar. It should be of a good height, and the ground plan will depend on the quantity of business to be done. The stacks, or beds, may amount to six in height, more or less according to the size of the pots.

A room for holding the troughs, and grooved cylinders, where the white lead is scraped from the blue lead. In this room, a pump should empty the contents of the first trough into others, after the water is well agitated;

so that the finer part of the white lead may gradually subside.

A room that will hold one or two pair of good millstones, with the necessary machinery, to grind the white lead first *in water:* with the shoots, tubs, &c. and utensils requisite for this purpose.

A drying room, that requires to be moderately heated.

A room to hold whiting, with which white lead is always plentifully adulterated. When added in the proportion of 10 or even 12 per cent. the lead is not much the worse as a paint: but when mixed, as it usually is, to the amount of from 20 to 25 per cent. it causes the paint to adhere but slightly, and to peel off from the wood.

A room to hold millstones wherewith the white lead should be ground up with whiting and *oil*, to sell as paint ready for use. Much of the profit of an establishment may be made to belong to this department of the manufactory. These two mill-rooms might be worked with the same machinery; and the drying room, and whiting room should be contiguous.

There should also be a room separate to prepare and contain a stock drying linseed oil, to grind up with the lead intended to be sold as paint.

For this purpose, a stock of litharge, and sugar of lead will be wanted, which may be best kept in the whiting room.

A store room.
A packing room.
A counting house.
} These apartments should be contiguous.

A cooperage and carpenter's room.

A lumber room.

Space for cart-ways, gang-ways, stabling, cart house, &c.

There will also be needed, in the common way, two

sets of cast-iron rollers, one fluted lengthway, and another crossway.

It is true, a manufactory may be carried on with fewer apartments, but very few of those I have mentioned can be dispensed with, in a manufactory on a tolerable scale. It should not be commenced under ten or twelve thousand dollars. Although white lead is a cash article, yet it must be remembered that blue lead is a cash article also, and the stock on hand will be of considerable value in a small compass.

Such an establishment ought to have a red lead manufactory connected with it: and by and by, the manufacturers here will find their interest in connecting with it, a manufactory of sugar of lead, and of pyroligneous acid.

The buildings will require *at least* 12,000 square feet on the ground plan. The power may be water power, horse power, or a steam engine.

Of Casting the Lead.—A man stands with a barrow, at the left hand of the smelter who also casts the lead into plates. He has two long ladles, one to lade out the melted lead, the other with a flat bottom, thirty inches long and six inches broad. Holding in his left hand the flat ladle, he pours on it from the other ladle in his right hand, (resting it at first on the edge of the pot that holds the lead) a quantity of melted lead, moving the right hand ladle down to the point of the left hand ladle, and gradually discharging its contents. Great part of the lead, runs off and falls on a table ready to receive it, but a part remains in the left hand ladle, covering the bottom thereof with a sheet of the above dimensions and about the eighth of an inch thick. The smelter, turns this off into the barrow, which when full, is wheeled away to the rolling room, and discharged upon the roller's bench, who turns it into a spiral of about three and a half inches diameter.

The top and bottom of the spiral roll, are kept as even as possible, that the cover may cover them closely and accurately. Sometimes sheets of lead are used flattened mechanically (milled) between two rollers: sometimes, a caster having melted lead poured into a case of the size of the proposed sheets, draws it into sheets by running a sliding piece of wood quickly along the edges of the frame or mould, and pushing the melted lead before it, thus forms it into a sheet.

The lead is then ready to be carried into the *corroding* room.

This room, is furnished with earthen pots which should be of stone-ware. They should be wide enough at top to hold a spiral roll of lead, which must rest on a ledge within side the pot about one-third or half of the way down: the pots may conveniently hold from one to three quarts of good vinegar, according to the size of the spiral which fills the top. The smelter or caster, making his sheets according to the size of the pots which the manufacturer thinks it convenient to use. The vinegar just reaches the under side of the ledge on which the spiral roll stands. The pots are placed on a layer of about three or four inches of horse dung, not quite close to each other all round the room, leaving a gang way in the middle. The lowest tier are then imbedded up to their necks in fresh horse dung, or tanner's bark. A piece of lead is then placed on the top of each spiral roll, and is then covered with a broad board. On this board another layer of dung with its pots, vinegar and spirals of lead is placed and buried up in dung or bark: and so on, as high as will admit of convenient management. The top tier, should be well bedded in dung and covered, because, it answers best to be examined from time to time to shew when the vinegar is all evaporated, which usually takes place in about two months. This top tier should be well

bedded in dung, that it may be a fair specimen of the general progress of the pots throughout the under tiers, which cannot be got at so easily. The stacks are taken down when the vinegar is evaporated, and the lead is carried into

The mill room. Here, the hardest, whitest, and most sonorous pieces of lead, are picked off and selected for the pigment usually as flake white; which is generally pure white lead unadulterated: and which may therefore serve as a comparison to ascertain the quantity of adulteration in common white lead.

The corroded plates are then run through the grooved rollers, and scraped. This is a very unwholesome part of the process. The men concerned in it, become paralytic in three or four years. An improvement has been made by a Mr. Archer Ward, in this part of the manufacture, which, although Dr. Coxe has copied it in the second volume of his series of the Emporium, and Mr. Cutbush also has copied it in his useful work entitled the American Artists Manual, yet, as I do not wish to send my readers hunting after processes to be found in other books, I chuse to copy it also in this. My plan being to accumulate all the useful information I can upon each subject, in one connected view: I am therefore not deterred by now and then a little repetition, or the insertion of papers which other works have stolen, before it came to my turn to pillage the rich store-houses of European information.

Mr. Archer Ward's account of his improvement is as follows.

Description of a method of preventing injury to the health of the workmen employed in preparing White Lead. By Mr. Archer Ward, in his own words:

IN order to explain, as well as I can, the advantages that will accrue to the workmen by adopting my inven-

tion, in preference to the common mode of preparing white lead, I will first state what the common mode is. When blue lead is in part corroded in the stacks, by an acid raised by a considerable degree of heat, brought on by horse-litter, the corroded and uncorroded lead are taken from the stacks to a room, called the engine loft, where a pair of iron rollers is fixed with a screen under them. The lead in this state is passed through the rollers and screen; from the motion of these rollers and screen, by which the white lead is separated from the uncorroded or blue lead, together with the moving the lead, in order to its being passed through them, a very considerable quantity of fine dusty white lead is raised, which almost covers the workmen thus employed, and is very pernicious to them. And not only in this part of the process are they liable to be thus injured, but they are again exposed to the dusty lead, by removing the blue lead from the screen-house to the furnace, as there still remains a quantity of the fine particles of white lead, which of course rises in removing it; and also, in removing the white lead from under the screen to the grinding-tub, a quantity of the dust arises, which is very detrimental to the people so employed.

My invention removes all these difficulties respecting the dry dusty white lead, so very injurious to the health of the working people; and consists of a vessel, as shewn in the plate,* fig. 1, twelve feet long, six feet wide, and three feet ten inches deep. In this vessel is fixed a pair of brass rollers in a frame, one roller above the other. The centre of the rollers is about ten inches below the top of the vessel; and, one inch lower, is a covering of oak boards or riddles, an inch thick, fixed in the inside of the

* See the next number.

vessel, in a groove, so as to be taken out occasionally; these boards are bored, with a centre-bit, as full of holes as may be, without danger of breaking into each other; the size of these holes is, in the machine at large, about five- eighths of an inch in diameter. This being done, the vessel is filled with water, about three inches above the oak boards or riddles; the lower brass roller is now under water, and about half of the upper roller is under water also. Thus the lead coming from the stacks, is put through the brass rollers in water, and, by raking the lead with a copper rake, over the oak boards or riddles, the white lead passes through the riddles, and the blue lead remains above; which, being taken out, is thrown upon an inclined plane of strong laths to drain, where it remains about 12 hours, when the blue lead is ready for the furnace to be re-melted; by this means no dusty white lead can rise in any part to the work-people. No such plan as this (though long desired) has, to my knowledge, been put in execution, so as to answer all the purposes above stated. It may be asked, why the lead in the common mode, is not made wet before it is passed through the rollers and screen. Should this be done, the lead would be a paste on the rollers and screen, and the white lead prevented separating from the blue lead, which is absolutely necessary in the preparation of white lead.

Reference to the Figure.

Fig. 1, A, an inclined plane of wood, on which the white and blue lead is placed immediately from the stacks, and thus introduced between the brass rollers BB.

CC, the vessel containing water.

DDD, the pierced oak boards or riddles, which, by being made to slide in grooves in the sides of the vessel CC, may occasionally be taken out by removing the wooden bar *ee*.

E, a handle or winch, which, in the machine at large, may be a wheel communicating to mill-work, and thus turn the rollers BB.

F, a pinion, fixed on the gudgeon of the upper roller, and communicating with a similar pinion on the arbor of the lower roller, keeping both of them in motion by the turn of the handle. As it is necessary that the upper roller should be at liberty to rise or fall, in order to give a due degree of pressure to the lead in passing between the rollers, two weights GG, with proper stems to them, are placed over the gudgeons of the upper roller, thereby keeping a due degree of pressure; and, if any piece of the lead should be thicker than usual, admitting the roller to give way to it, and thereby preventing any injury to the machinery.

H, a notch in one side of the wooden vessel, serving to regulate the depth of the water on the riddles DDD.

The foregoing description is accompanied by two certificates; one from Mr. Samuel Walker Parker, stating that many tons of white lead have been made, in the manner above described, at the manufactory at Islington, belonging to Walker, Ward, and Co. and that, since Mr. Ward's plan was adopted, no other method has been used. The other certificate is from Mr. H. Browne, of Irongate, Derby; who says, that he thinks the foregoing invention a very valuable improvement in preparing white lead, and that the quality of the lead is not in the least injured by it.

Mr. Wetherill, of Philadelphia, obtained a patent for a somewhat similar contrivance."

The white lead, thus being scraped and rolled off from the blue lead, the latter is sent back to the smelting room, and the white lead agitated in water, then pumped up into other troughs to drain: the refuse of the first troughs is also conveyed to the smelting room.

When the white lead washed and drained, is of a pasty consistence, it is well ground between two mill-stones, and from the troughs that receive it, is carried to the drying room to dry upon porous pans. When whiting is mixed with it (which is always the case) the whiting ought to be well washed in troughs to carry off the dirty part: then it ought to subside, and the water drained away. Then it should be washed again for the coarser and sandy parts of the whiting to subside, and the finer parts of the whiting only should be taken, and a second time (after being mixed with the white lead as well as possible in the troughs) passed with the lead in a state of mixture through the mill-stones. Then dried together in the stove room.

From the stove room, the lead is conveyed to the store room, and thence to the packing room.

Such is the common method of making white lead; a process sufficiently complex, troublesome, and unscientific. The substitution of tanner's bark for dung, is an improvement in respect to cleanliness, but I do not know that it is superior in any other way.

The substitution of a stove, whose flues might be conveyed among the pots, or the heat of the room kept up to the necessary degree, regulated by two or three thermometers, would in my opinion be a considerable improvement.

But when I went through the vinegar manufactories of England, I was struck with the obvious application of the processes there used, to the manufactories of *white lead* and of *verdigrease*: and I propose it without hesitation to the manufacturers here, as a combination of processes that cannot but prove economical and lucrative. I do not expect however that it will be put in practice, till on reading this, some speculator in patent rights, will take out a patent for it, and swear in the usual way that he is the true and original inventor. I have already detailed a process

of bleaching by means of red lead, so easy, so speedy, so practicable, and so economical, that no one who has tried it, would hesitate for a moment to prefer it to the bleaching by manganese, even if the latter substance could be obtained for nothing. I have had bleached under my own inspection by this process, more goods in a week, than any manufacturer of cotton goods of whatever species in this country, manufactures in a year. Yet bleaching by manganese, imported at an extravagant rate from Great Britain still continues in use, even among the best informed manufacturers of cotton articles in this country. However as the process is my own, I now give notice that I will take out a patent for it; and then perhaps, it will be thought of some value, when some value is paid for the liberty of using it. Having turned my attention early, to anatomy and physiology, and to medicine also, as well as chemistry, I have for many years practised among my friends, among the poor, and wherever my neighbours of the medical profession thought fit to consult me upon any case, curious or difficult. But as I have never directly or indirectly accepted any thing in the form of a fee for my trouble, I am frequently obliged out of sheer good will to my patients, to advise a physician to be called in because my prescriptions really do no good for want of faith in their efficacy, until the patient has to pay for them. Some physician of eminence in England, I forget who, is said, always when he took medicine for his own indisposition, first of all to take a guinea out of his right hand pocket and put it into his left hand, as a sum to be religiously spent in some act of charity; otherwise he would have doubted the efficacy of his own advice. Indeed it is true universally, that the world never feels grateful to those who benefit them gratis: they only are respected, who setting a proper value on their services exact the highest price for them. People take for granted from an intimate

knowledge of their own dispositions, that you would never give, except what was of little worth. If you set no value on your own property, what obligation is there on the public, to consider it as valuable? I forgot to mention that in my patent for bleaching, I mean to include the manufacture of white lead, as connected with it. I know of no means so proper to make the process of value to the public, and introduce the use of it.

But to my immediate purpose. The process of making white wine *vinegar* in England is as follows.

In an oblong room heated by stoves to the degree of about 80 of Fahrenheit, place upon tressels a series of quarter casks, high enough from the floor for a pail or tub to stand conveniently under the casks, from which the liquor is drawn. The top of the quarter casks is pierced full of auger holes. The casks are filled with cyder. On the top of the casks, is placed a tub full of Malaga raisins, the bottom of the tub being likewise pierced with auger holes. A man is employed from morning to night, in going round this series of quarter casks, and drawing from the bottom of each, a pail or bucket full of cyder, which he pours on the top of the Malaga raisins. The cyder percolating through the body of the Malaga raisins, acquires a saccharine mucilage, together with a vinous flavour; and by degrees is converted into vinegar. The raisins may be employed with a little addition to give flavour to two casks of vinegar. When the cyder is thus converted into vinegar, it is drawn off, and the casks being replenished with cyder, the same routine is again pursued. The vinegar is fined with white of egg, racked off, and is then ready for sale.

During the percolation of the vinegar through the Malaga raisins, so much acetous acid evaporates and is wasted, that if plates of sheet lead or copper were hung up in the room, a manufacture of white lead or of verdigrease,

would be established to a considerable extent and at no expence. When I suggested this to a vinegar manufacturer in Gloucestershire, whose works I examined, he promised to give it immediate trial; but I left the country without an opportunity of knowing whether he did so or not.

I have already mentioned, that the process of making carbonat of lead, by precipitating the nitric or acetic salts of lead, by carbonat of potash, although the article be very white, is too dear for a manufacture in the large way. The carbonat of lead thus made, on an average of the experiments of Bergman, Berthollett, Klaproth, and Chevenix, consists of 84,13 lead, and 15,87 acid. But the carbonat of lead can be made by treating the sulphat and muriat of lead, which, form the refuse in my mode of bleaching, with carbonat of potash; a process which belongs to, and is part of the process, I claim to myself; and which, until I procure a patent for it, any one is welcome to use.

I come now to the neatest, most scientific, and most economical method of making white lead, founded upon Lord Dundonald's patent of decomposing the muriat of potash, by litharge or any oxyd of lead. To make this perfectly intelligible, I must go back to the history of *Turner's mineral yellow;* the common, heavy, hard, fused, patent yellow of the colour shops, and in common use with the coach-makers and chair-makers. Turner took out a patent for making this colour about eight and twenty years ago, which being contested, was set aside, owing to the gross ignorance on the subject, of the Court of King's bench and the bar.

Turner, by a mill-stone rolling vertically in a circular trough, triturated for 12 hours together in the form of a paste, two parts by weight of common salt, and one part of litharge. He would have done better by three parts of

common salt as I think. By degrees, and by remaining together for twelve hours more, the common salt became decomposed; a muriat of lead was formed, and pure soda, the basis of the common salt. The pure soda was drained first and the remainder washed away, and boiled down to chrystallize, in a room where charcoal was burnt in braziers, to supply carbonic acid gas. The pure soda would not decompose the muriat of lead, there being only *one* divellent affinity, viz. that of soda.

The lead thus freed by washing from the soda, was put into crucibles and fused in a strong heat. It then became a yellow chrystallized mass, the patent yellow of the shops. The soda when chrystallized, was disposed of as carbonat of soda.

Now, if the soda, instead of being washed away, had been left quietly to gain from the atmosphere or elsewhere its carbonic acid, being still in contact with the white, moist, muriat of lead, there would have been *two* divellent affinities, and a double decomposition would have taken place: the carbonic acid would unite with the lead, while the muriatic acid would again unite with the soda, reproducing the original quantity of common salt, which might be washed away, re-chrystallized, and used again for the same purpose. The carbonated lead thus produced would be *white lead.*

Lord Dundonald discovered, that although common salt and various other alkaline neutrals would answer the purpose, the decomposition went on best with muriat of potash, instead of muriat of soda. And in this way is the greatest proportion of English white lead now made.

In England, the making of white lead, is connected with the manufactory of soap; almost all the alkali now used for soap being procured from the decomposition of neutral alkaline salts by means of oxyds of lead. For by thus procuring them, the expence of rendering the ley

caustic by means of quicklime is superceded, and the trouble and expence greatly economized.

I prognosticate, that whoever will commence in this country, the manufacture of white lead connected with the manufacture of cyder-white-wine vinegar—or the manufacture of white lead by the decomposition of alkaline neutral salts, connected with the making of hard soap—will, if there be sufficient capital, skill and industry, make a profitable concern.

We have no business in this country when peace comes, to import lead from England. The Louisiana country is amply sufficient to supply all our wants: and ere long, the atlantic states will be supplied from thence not merely with blue lead, but with red lead, massicot, litharge, white lead, and shot; for all which, the materials and conveniencies of situation are abundant in that country.

To the Editor of the Monthly Magazine, May, 1809.

Sir—I am informed that, in consequence of an alteration (lately made) in the process of drying *White Lead*, the health of the labourers, in an extensive manufactory in the neighbourhood of London, has been very materially benefitted—the fatal *constipation of the bowels*, so common amongst them, having much decreased, which is attributed in a great measure, if not entirely, to this alteration. The different mode of drying the lead adopted is (if I understand the matter right), that instead of laying it on chalk, it is now poured into earthen-ware pans, and left to dry in them; the lead does not undergo nearly so much handling as before, and the fine particles of it, which used to float in great abundance about the room, are not perceived in such dense clouds as they used to be; this dust entering the mouth was one principal cause of the diseases to which the workmen were liable. By means of your miscellany, I wish to give publicity to the

above circumstance; and should any of your readers be able and willing to give me any further particulars respecting this manufacture, which may be conducive to the health of those employed in it, they will much oblige

A CONSTANT READER.

Mr. John Brierley's (Greenfield, Flintshire,) Patent for a new mode of setting Blue Lead for corroding the same into White Lead.

THIS method, by means of a bed of dung or bark, into which are inserted pots filled with acid; over these are placed boards having holes bored in them to admit the vapour of the acid round the rolls of lead. On these another bed of dung or bark is placed, and the process repeated before, forms a second bed; these beds may be repeated to any practicable extent, and are denominated a stack. There is a chimney or flue running through all the beds, for the purpose of distributing the vapour of the acid equally through them all, for which purpose that part of the flue, which extends from the one bed of dung or bark to the other, is left with small interstices between the bricks, so as to communicate any superfluous vapours above or below, or carry off to the other bed any vapour which may be to spare in that bed.

The observations of the patentee refer 1. To the number of pots, and the difference as to the expense of them. 2. To the health of the manufacturers. 3. To expenses of the annual breakage.

With respect to the 1st. Aceording to the above plan a bed may be set with 280 pots of equal effect with a bed, which, according to the old mode, would require 560 pots, making a difference of one half. The pots used in the plan cost 2d. each; those in the old method 5d. each. So that 280 pots at 2d. each will cost 2l. 6s. 8d. and 560 pots at 5d. will cost 11l. 13s. 4d. leaving a difference in

favour of the plan of 9l. 6s. 8d. for each bed. Now if a stack consists of seven beds, and the manufacturer raises nine stacks, the gross amount of the saving, in the first instance, will be 588l. According to this plan the manufacturer can set three tons of lead in a bead, when in the old way he can only set about 1 ton 12 cwt.; and the corrosion is more certain, from the fumes of the acid having free access to all the lead, which is placed upon the boards, instead of the rolls being confined separately in the pots along with the acid; that the pots, which are placed under the joints of the stack-boards, will be filled with liquor or acid neutralized by being mixed with the ooze in the bark, and the fumes arising therefrom being condensed, the pots become filled, and the necessary corrosion is therefore prevented. From this mode of setting lead, the manufacturer will obtain a third more of white lead than according to the old way.

2dly. The plan clearly demonstrates, that the rolls of lead being placed upon boards are easily taken off when corroded. When the stack boards are removed, the rolls should be well sprinkled with a watering can, which will prevent the dust from rising and annoying the labourers. Now, according to the old way, if the lead is well corroded, the expansion becomes so great as to fill the pots tight and close, and the labourer, in order to disengage the ceruse from the pot, is obliged to knock it upon the taken-off boxes, which causes a dangerous dust to arise, that affects the labourer with that most dreadful disorder, the colic of minerals*.

3dly. The breakage of the pots according to this plan, is not as one pot to thirty in comparison of the breakage arising from the mode of setting. For experience tells us, that in the old way, we may expect a loss of 30 pots in 560, and of course in a stack 210, and in 9 stacks 1890 pots. Supposing the manufacturer to take up and

* Colica pictonum. Colic of Poictou, and Devonshire

set four rounds of stacks in one year, the number of pots broken will be 7560, which, at 5d. each pot, amounts to 157l. 10s. These nine stacks of pots in the old way would cost 735l.; according to the new plan only 147l. leaving a difference of 588l. as stated under the first head of observations. Exclusive of the savings before enumerated, it must be of very great benefit to the manufacturer that he can bring into the market, in the same given time, a third more of white lead by pursuing the plan before specified, than by the old modes.

27 *Month. Mag.* 331 *and* 588.

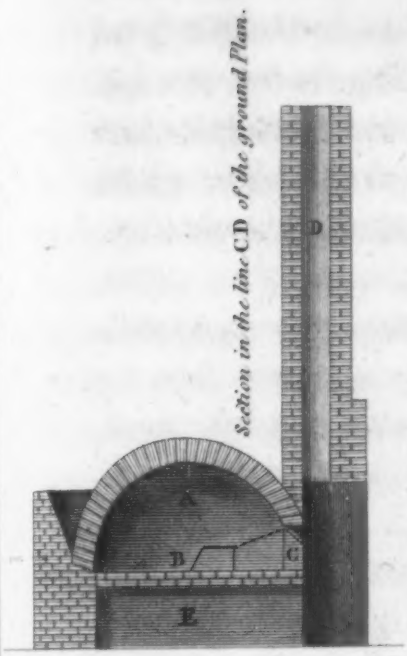
RED LEAD.

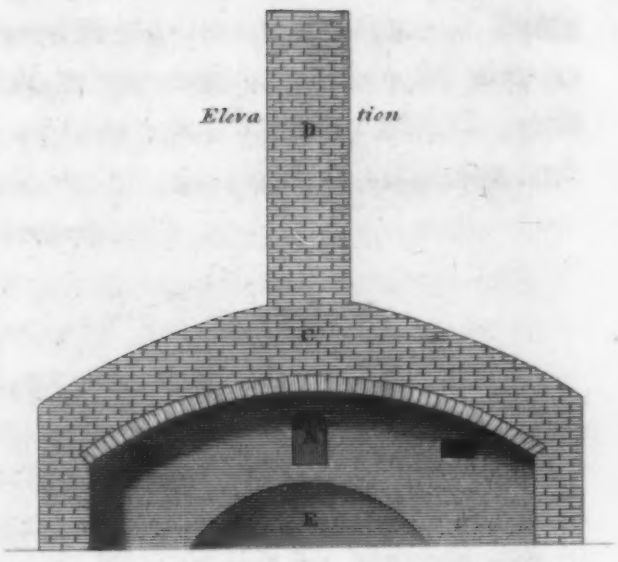
I PROCEED now to the manufacture of *Red Lead* and massicot; but I must defer the plate I propose to attach to my account of this manufacture to the next number, the present being supplied with the usual quantity, and not being able to procure in time the engravings necessary to illustrate the subject of lead.

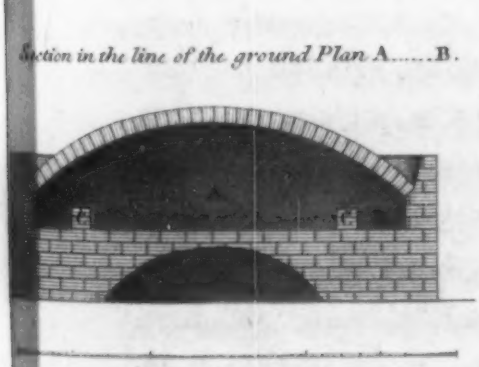
The following account of red lead from the excellent Essays of Bishop Watson (of Landaff) is proper to introduce the subject.

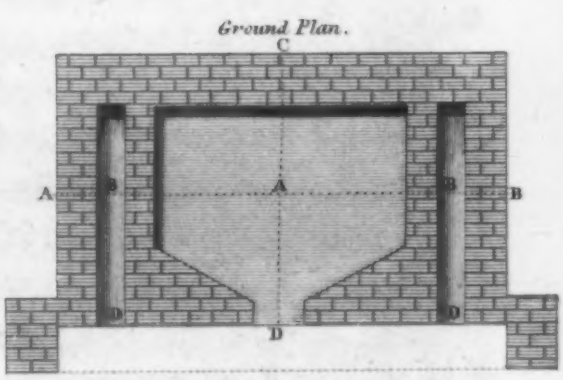
"IF the reader does not know what *minium* or *red lead* is, I would wish him to send for a few ounces of it to his painter or apothecary. Supposing him to have a parcel of red lead before his eyes, the first thing which will strike him is its vivid colour verging a little towards orange; if he crumbles it between his fingers, he will find it to be an almost impalpable powder; if he poizes it in his hand, he will perceive it to be much heavier than either brick dust or red ochre, with which substances it is sometimes adulterated; if he compares it with a piece of lead, he will be astonished how it can be either produced

Red Lead Furnace.









H. Anderson fc.

from lead, or be capable of being, by a very slight operation, *reduced* into lead again.

It has been mentioned in the preceding essay, that red lead is made from *litharge* at Holywell: this red lead, which is made from litharge, is not perhaps, in all its properties, of quite the same kind with that which is made directly from lead; at least I have been informed, that the makers of flint glass, who use much red lead in the composition of that glass, are of opinion, that the litharge red lead does not flux so well as that which is made from the direct calcination of lead, as is practised in Derbyshire. There are in that county nine red lead mills or furnaces, all of which are much upon the same construction.

The furnace is very like a baker's oven, its vaulted roof is not a great distance from the bottom or floor, on each side of the furnace there are two party walls, rising from the floor of the furnace, but not reaching to the roof; into the intervals, between these walls and the sides of the furnace, the pit-coal is put, the flame of which being drawn over the party walls, and striking upon the roof, is from thence reflected down upon the lead, which is placed in a cavity at the bottom, by which means the lead is soon melted. The surface of melted lead, when exposed to the open air, instantly becomes covered with a dusky pellicle; and this pellicle being removed another is formed, and thus by removing the pellicle, as fast as it forms, the greatest part of the lead is changed into a yellowish green powder. This yellowish powder is then ground very fine in a mill, and being washed, in order to separate it from such parts of the lead as are still in their metallic state, it becomes of an uniform yellow colour, and, when it is dried to a proper consistency, it is thrown back again into the furnace, and being constantly stirred, so that all its parts may be exposed to the action of the flame of the

pit coal, in about 48 hours it becomes *red lead*, and is taken out for use.

The colour of the red lead admits some variety, which is occasioned by the different degrees of heat. If the heat is too small, instead of red it is yellow or orange coloured; if it is too great, the red colour is changed into a dirty white, between these two extremes it is subject to some diversity of shades of red, which cannot be well noticed or described, except by those who are engaged in the making of it.

It has been asserted, that the reverberation of the flame and smoke upon the surface of the lead, is not a necessary circumstance in giving it a red colour, but that it will acquire this colour by a long calcination without coming into contact with the flame. The truth of this assertion I think may be doubted. I have more than once calcined lead for above 60 hours, without suffering the flame of the fire to touch it during any part of the process, but by this method I could never obtain any thing better than a dirty red, resembling the red of brickdust, which is very different from the colour of red lead; and even this dirty red was changed into a yellow colour, by augmenting the degree of heat with which the lead had been calcined. The method of making red lead is very well understood in England and Holland, but not in France; and the French workmen are of opinion that it cannot be made by the flame of wood fires.*

During the making of red lead, part of it is volatilized, there rises up from it a vapour, which attaches itself to the roof of the furnace, and forms solid lumps. These lumps are of a yellowish white colour mixed with pale green and some reddish streaks, wherein are frequently small red crystals, resembling such as may be artificially form-

* Mem. de l'Acad. des Scien. 1770. Elemens de Mineral, par M. Sage. Vol, 2. p. 248.

ed by subliming sulphur and arsenic together. The workmen call the whole of what is separated from the lead in the form of smoke, sulphur: when this sublimed matter is detached from the roof of the furnace, the red parts are converted by a subsequent process, into red lead; and the yellow ones are sent to the smelting furnaces, to be run down again into lead. The quantity of this sublimate amounts to about five hundred weight in making one hundred tons of red lead. The proportion here assigned is not wholly to be relied on, since the smoke arising from the lead forms itself into larger masses, and in less time, when it is not constantly swept from the roof of the furnace than when it is; and the workmen endeavour to keep the roof as free from it as they can, because a small portion of it injures the colour of a large quantity of the red lead with which it happens to be mixed.

A ton or twenty hundred weight of lead generally gives twenty-two hundred weight of red lead, notwithstanding the loss of substance which the lead evidently sustains from the copious smoke which arises from it during the operation." [3 *Watson* 337.

The method of making red lead in England: from Jar's Voyages Metallurgiques, vol. 2, p. 569. There are two manufactories of red lead in Derbyshire, at Chesterfield and at Worksworth. The furnace appropriated to this operation is a reverberatory with two fire places under one and the same arch, which are separated from the floor in the middle of the furnace by a wall on each side about 12 inches high. Each fire place is about 15 inches wide, and runs the whole length of the furnace from the front to the back or about 9 feet. The distance between the fire places on each side is about ten feet. The mouth or front opening of the furnace is about 19 inches by 16 in height: neither this opening, or those of the fire places on each side of it are ever closed. They are all situated under a

high chimney, common to them all, and opening inside; so that the furnace is in fact a common baker's oven, of which, the bottom by two walls running the whole length of the arch, is divided into three parts; the middle being the hearth on which the lead is placed, in size about 10 feet by 9 feet, the other two parts on each side being fire places of which the dimensions are 9 feet by 12 inches and 15 inches. These fire places have neither grate or ash hole. The coal in middling sized lumps is thrown into these fire places, which it fills to the level of the side walls (that is 12 inches high.) The hearth is accurately and neatly laid with fire brick, with very small joints and is perfectly level. The hearth is common, extending from the springing of the arch on one side, to the springing of the same on the other,

About fifteen hundred weight of lead is the common charge of the furnace, of which about one-tenth is slag-lead, (procured by working the slags over again). The workman begins by forming a ledge just inside the mouth of the furnace, of the yellowish slag or refuse of the washing of the red lead of the preceding charge: this serves to keep in the melted lead during the operation. The flame from the coal fire on each side strikes against the roof of the arch, and is reverberated downward on the surface of the metallic lead on the hearth. During all this time, a man standing in front of the furnace, rakes the melted lead with an iron rake which is suspended by a chain hung on the outside of the mouth of the furnace, so that the man's hands are freed from the weight of the rake, and he has nothing to do but push it backward and forward. As the oxyd forms, he draws it to one side leaving the centre of the hearth filled with melted lead, of which by the rake he continually exposes fresh surfaces, until the whole is converted into a dusty oxyd. This requires from 4 to 5 or 6 hours. The whole of the

lead however, is not converted into oxyd. There are always some refractory lumps remaining, which are collected, melted over again, and worked up in the next charge. (These are probably parts of the lead, alloyed with silver, zinc or antimony, or all three.)

The fire is well kept up during the whole time; but as the mouths of the furnace and also of the fire places are kept constantly open to expose the surface of the lead to the air, the heat never exceeds a full cherry-red. The smoke and dust passes up the chimney situated over the mouth of the furnace.

At the end of about 5 hours the lead is converted into grey ashes, but it takes a continued heat of about 24 hours to convert it into massicot; during this time, it is raked just enough to prevent its clotting, and forming lumps, as well as any tendency to fusion. It is then raked out upon the floor of the apartment which is well and neatly paved with hard brick. In this state while on the floor, it is wetted with water and raked; and when cold it assumes the colour of yellow ochre. In this wet state it is taken away and ground between two mill-stones. But this operation does not grind it fine enough. Hence, after it has been discharged from the mill-stones into the tub placed to receive it, a man takes it up in a copper basin, and agitates it under water in another vessel, until by turning the basin round backward and forward in a half circle, all the fine part is washed out of the basin and falls into the tub of water, while the coarse sediment in the basin, is thrown aside, either to be ground or remelted. It is this sediment which is employed to form the dam or ledge in front of the furnace, used to keep in the charge of melted lead. The massicot so ground and washed, subsides; the water is turned off from it, and it is then carried to the furnace again for the next operation. Some manufacturers use the same furnace; others more con-

veniently have another furnace of the same kind for the conversion of massicot into minium or red lead.

The yellow sediment is now carried to the hearth of the furnace: the fires on each side are lighted, and kept up as before. As the coaks or cinders form, they are raked out and fresh coals put in. The yellow oxyd is now stirred only often enough to keep it in a separate and powdery state, and very gradually to expose fresh surfaces to the air. In from 40 to 48 hours, the yellow colour gradually disappears and is converted into a deep brownish red. (This is in my opinion the puce coloured per-oxyd of lead.) But when cold, this brownish red, passes into the bright red of the minium or red lead of commerce. When taken out of the furnace, it is spread over the surface of a large box to cool. It is then passed through a sieve in a close vessel, to prevent loss, and collected for sale.

The coal used should be but moderately bituminous, evidently because the carbonaceous smoke retards the oxydation. The coaking, Newcastle coal, is usually preferred in England. They are persuaded that red lead cannot be made with wood. It may be more difficult, partly on account of the smoke, and partly on account of the acid vapour of wood unless it be very dry. Certainly red lead cannot be made by applying the heat externally: it must be applied to the surface of the lead.

I shall give a plate of the red lead furnace in my next.

The *litharge* of commerce is the refuse of the refining furnaces, although it can be made also in the red lead furnaces. The lumps of lead that cannot easily be converted into oxyd, might as I think be advantageously thrown aside, for refining; the silver, if they contained it, would doubtless be an obstacle to the oxydation. Litharge, seems that state of lead, best adapted to the decomposition of alkaline neutrals; but I do not know that Dr. Thompson's opinion has been established, that it is in any degree

a carbonat of lead, though the rationale of the process by which it is made, would point out the formation of the carbonic acid, during the process of refining lead.

By accident I mislaid the following important memoir on the refining of lead and the making of Cupells or Tests. It is from the Journal des Mines, No. 64.

Memoir on the Refining of Lead; with some reflections on the inconvenience of Ash Cupells; and the description of a new and economical method of constructing Cupells or Refining Vessels: read in the French National Institute. By C. DUHAMEL, *Member of the Institute and Inspector of Mines.*

It is well known, that to separate silver from lead, a metallurgic process called refining or cupellation, performed in a vessel called a cupell, has been employed: it is known also that this vessel is composed either of the ashes of the bones of animals, or of those of vegetables, after they have been lixiviated, to free them from the saline matters which they may contain.

The great quantity of wood-ashes which must be employed in the construction of cupells, and the difficulty of obtaining them, long ago induced me to endeavour to discover a simpler and less expensive method of constructing the vessels in question. The old chemists having observed that lead becomes oxydated, or reduced into what is called *litharge*, when exposed to heat, or the contact of the atmospheric air, while the silver united to it retains its metallic form, nothing seemed necessary but to find the means of separating these two metals. They were conducted to the method of accomplishing this by observing that the oxyd of lead, in its state of liquefaction, easily penetrates the substances which are in contact with it, and especially bone-ashes, without deforming the ves-

sels which are formed of them. No matter, indeed, is more proper than the latter for constructing small refining cupells.

The difficulty, and often even the impossibility, of obtaining about 160 English gallons of ashes for each operation of refining on a large scale in the German furnaces, made the proprietors have recourse to wood-ashes; but, besides that these ashes are expensive, it often happens that they cannot be procured in sufficient quantity. They are even attended with one inconvenience, which is, that they come off, and float on the fused lead; the refining then fails: and this takes place every time that the ashes are badly prepared, that the cupell is insufficiently or not uniformly beat, or when the canals destined for the evaporation of the moisture are neither in sufficient number, nor properly arranged, nor covered with a stratum of scoriæ, on which is established the bottom, that receives the ashes, and which ought to be constructed of the most porous bricks, in order that the water, with which it is necessary to moisten the ashes, may penetrate them in evaporating, may proceed to the bed of scoriæ, and escape by the spiracles which are at the base of the furnace.

To ascertain the proportion of lead in silver, it is sufficient to put some pennyweights into a small cupell of bone-ashes placed under the muffle of an assaying furnace. In proportion as the lead becomes oxydated, it insinuates itself into the cupell, and the silver at last assumes that vivid appearance which announces that the whole lead is dissipated, that the silver it contained is refined, and has attained to its *maximum* of purity.

In refining on a large scale, the object also is to separate the silver from the lead, but not to make the whole of the latter penetrate into the cupell, which is even impossible; for in that case it would be necessary to have a much larger quantity of ashes for the total absorption of

the metal: besides, the operation would require a period ten times as long as that used in general for refining, and would occasion ten times the expence in fuel, and a much greater loss of the metals than by the usual process, where the greater part of the lead is obtained in litharge, while a portion penetrates into the cupell for about two inches of its thickness, which must be fused to revive the lead. This reduction is also more expensive, and experiences a greater loss than the litharge, which is easily fused, and which, without passing through the furnace, may be employed as an article in commerce.

Lead ore and litharge may be fused as in England, and the department of the ci-devant Brittany, in a reverberating furnace the soles or basons of which are formed of pounded and moistened clay. These soles can stand the action of heat and of the oxyd of lead for six or eight months of uninterrupted labour.

The durability of these earthen soles gave me the first idea of the method, which I shall hereafter propose, for refining-furnaces, where the only thing required is to oxydate the lead to obtain it in litharge, and not to cause the cupells to imbibe the whole of it, as is done when the object is to assay the metal in order to know whether it contains silver. In operating on a large scale, the cupell, though of ashes, absorbs only a part of the lead, as I have already said, observing at the same time that it would be much more advantageous to obtain the whole transformed into litharge, the reduction of which into lead is much easier than that of the oxyd contained in the ashes, which oppose fusion, and the scoriæ of which always carry with them some of the metal.

In a cupell of ashes beat into an oval circle of iron, the greater diameter of which is only five or six feet and the less one yard, the English refine from a ton to 23 cwt. of lead, which is converted into beautiful litharge, except the

small portion which penetrates into the cupell, the thickness of which is only about 2 3-4 inches, and which is supported under the arch of the furnace by two bars of iron. A pair of leather bellows drive the litharge towards the anterior part of the furnace, from which it falls, without interruption, on the floor of the foundry, while, to fill up the vacuity left by the oxyd running off, an ingot of lead placed close to the base of the bellows is made to advance gradually into the interior part of the furnace. This lead, by fusing, keeps the cupell full till towards the end of the operation.

If I have here given a short view of the process of the English, it is only to shew that it is possible to perform operations of refining by employing only a small quantity of ashes for the construction of cupells. Those in question do not absorb 90 pounds of oxyd in the large quantity of lead which is refined.

It is then proved that metallurgists have always endeavoured to obtain the greatest quantity possible of litharge, and little ashes impregnated with oxyd; but as they thought that they ought not to deviate from the docimastic process, they have always constructed their cupells of ashes.

It has been seen that in cupellation on a small scale, lead, in proportion to its oxydation, penetrates the ashes. When no more is left, the small button of silver remains pure at the bottom of the bason under a spherical form. This operation takes place with the more celerity, as the surface of the mass is always convex in these small vessels; which allows the oxyd to flow as on an inclined plane, towards the edges of the cupell, where it is immediately imbibed.

The case is not the same with cupells on a large scale, which are several yards in diameter: bellows must be applied, the wind of which serves not only for accelerating

the oxydation, but also for driving the litharge towards the gutter formed for its escape.

We have remarked the inconveniences and even the impossibility of making the whole lead penetrate into the ashes of large cupells: oxydation, indeed, is not effected but in the parts of the mass exposed to the contact of the air or to the wind of the bellows; but as litharge, towards the middle of the bason, could not reach its edges, it would remain there in a state of stagnation, and would necessarily oppose the formation of a new stratum of oxyd. This has induced metallurgists to expel the litharge by the wind of a pair of bellows in proportion as it is formed, and to make it flow from the furnace.

Oxydation then take place only at the surface of the mass, and not at its lower part: if the case were otherwise, the ashes of cupells would be penetrated by the oxyd to a thickness the more unequal, as the operation is longer; but I have always remarked, that the *test*, or the part of the ashes impregnated with litharge, in refining on a large scale, is not thicker in the centre of the bason than towards its circumference, though the lead remains thirty or forty times as long in the bottom as on the edges; since the mass continually decreases till the whole lead is reduced to litharge, and till nothing remains but a cake of silver at the bottom of the cupell.

If the whole lead is imbibed by the assaying cupell, it is because this small vessel is exposed to a heat uniform in all its parts. As the cupell, in operations on a large scale, presents to the action of the caloric only its upper surface, the oxyd imbibed ceases to penetrate it at the place where the temperature is no longer high enough to keep that oxyd in a state of fusion. For this reason, the thickness impregnated is equal throughout the whole extent of the cupell; and this prevents the possibility of making the whole lead penetrate into the ashes.

From the above observations it may easily be conceived, that if the assaying of lead ought to be performed in small cupells of bone-ashes, in order that the oxydated metal may penetrate them, and be in part evaporated, the case is different with refining on a large scale, where it is necessary to accelerate the operation, and to obtain as much litharge as possible.

I have already said, that the wood ashes of which cupells are made for refining on a large scale are expensive; that very often a sufficient quantity cannot be procured; and that besides this, part of the ashes, and sometimes the whole, separate themselves entirely from the sole; which occasion a considerable loss. I shall add, that to give more weight and consistence to the cupells, it is often necessary to mix with the ashes a large quantity of sand; especially if the lead contains foreign substances, such as arsenic, cobalt, antimony, tin, &c. If the lead be only arsenical, after having separated the first scum, a quarter of a hundred weight of iron filings or cast iron turnings are now and then thrown over the whole surface of the mass. This iron, being lighter than lead, floats over it and absorbs the arsenic, after which the mass must be scummed: soon after, the litharge is formed without any obstacle. This method is employed in Saxony.

The necessity of adding sand to the ashes of cupells must have conducted to the discovery of the following means, which I shall here propose.

New Method of constructing Basons for Refining.

Without making any change in the mason-work of the refining furnace, called the German, care only must be taken to form at the bottom a sufficient number of canals for the evaporation of the moisture, and to arrange them in the manner best calculated to produce that effect. These canals or spiracles must be covered with a bed of

scoriæ, over which a pavement is to be made of one layer of the most porous bricks.

On this area, which must be concave like the sole on which the ashes of common cupells are beat, place founders' sand a little moistened; to which may be added a fifteenth part of argil, if it is not sufficiently earthy, in order to give it the requisite solidity; and the whole must be carefully mixed. This sand must be rammed in the same manner as for consolidating ashes; and a refining bason is to be formed in like manner, uniformly beat in all its parts. The thickness of this cupell must be six or seven inches: it may be formed of two strata, as will be seen hereafter.

After the bason has been uniformly beat in every part, about a gallon of lixiviated wood-ashes may be sifted over its whole surface, and rendered adherent with beaters.

When the cupell is thus prepared, let down the head on the furnace and make a moderate fire in the fire-hole; which must be maintained for several hours, in order to cause a part of the water, with which the sand has been moistened, to evaporate. The surplus will be dissipated during the operation, without any inconvenience, by canals of evaporation.

After a sufficient desiccation, raise the head and suffer the cupell to cool a little; spread out straw or hay over it, and arrange the ingots of lead, placing them gently on it that their weight may not derange the sand: it is to prevent such derangement that straw is employed, as is done in regard to cupells of bone-ashes.* When the quantity of lead necessary for filling the cupell is arranged in the furnace, let down the head, and, having luted it round

* Instead of prismatic ingots it will be better to cast the lead in hemispherical iron moulds. Pieces of that form are less liable to damage the cupell.

with soft clay, make fire in the fire-hole as for the common operations of refining.

When the lead is in complete fusion, and the mass is covered with scum and charred straw, make the scum or dross run off by the gutter for the litharge with a bit of board about a foot in length, in the middle of which is fastened a rod of iron of sufficient length to traverse the furnace and about a yard more.

When the lead has been well scummed several times, and begins to be red, make the bellows act, but at first gently; arrange the nozzles of them in such a manner, that the wind issuing from both may be directed to the centre of the cupell; and in order that the wind may be always reverberated on the mass, adapt to the extremity of each nozzle a small round piece of iron plate. This kind of valves, which the French refiners call *papillons*, is employed for refining according to the German method. They are suspended by hinges at their upper part: at each stroke of the bellows they are half raised, and they reverberate the wind on the lead, which accelerates its oxydation.

After all the dross or scum is removed, and when the lead has become exceedingly red, and covered with a stratum of litharge, form, with a small iron hook destined for that purpose, a small gutter in the sand of the cupell, which must be dug deeper, gradually and with caution, until the bottom of it be on a level with the mass. The litharge then, driven by the wind of the bellows towards the anterior part of the furnace, will run by this gutter and fall on the floor of the foundry, as is the case in the common operations of refining.

When the refiner observes that no more litharge remains in the neighbourhood of the gutter, he will stop the flowing off with a small quantity of moistened ashes: but as soon as the lead again becomes covered with oxyd,

the gutter must be opened, and must be dug in proportion to the diminution of the mass, taking care that no lead escapes, and particularly towards the end of the operation; for it would carry with it a great deal of silver, which would be lost. You must proceed in this manner till the silver has acquired its vivid colour; taking care to increase the fire in proportion to the diminution of the mass; especially when the operation is nearly terminated, because the silver then is collected together: and, as it is much more difficult to be kept in fusion than the small quantity of lead which remains united with it, it could be refined only in an imperfect manner at an insufficient temperature; and instead of about a twentieth of lead, which the silver generally contains in the German refining-houses, it would remain charged with a great deal more, which would render it more difficult to proceed to a second operation, called the *refining of silver*, by which it is carried to the required degree of purity. The Germans call this second process *silber brennen*, burning silver.

Those accustomed to the refining of lead according to the German method, will be able to perform that which I here propose; for, though the cupell be of sand instead of ashes, the operation must be conducted in the same manner.

It has been seen that the English refine a large quantity of lead in a small cupell: in the like manner, a great deal of metal may be made to pass by that which I propose, if care be taken to add more metal as that which is oxydated escapes. If we suppose that the cupell is capable of containing four or five tons of lead, above sixteen may be refined at one operation; which will not be attended with the inconveniences of the English process.

I have reason to think that a cupell of sand well constructed may serve for several operations without the necessity of re-constructing it each time, as is the case with

those of ashes; but in this case, and before the lead is introduced, you must fill up the gutter which has been made for the litharge to run off, after having removed with a chisel the kind of varnish which the oxyd of lead has left on the sides of it, in order that the new sand, somewhat moistened, may form an intimate connection with the old sand, which must also be watered in that part before the new sand is deposited.

The long duration of earthen soles in reverberating furnaces, where lead ore and even litharge are fused, as I have already mentioned, leaves no room for apprehension in regard to the action of the oxyd of lead, which will act only at the surface of the cupell, and will penetrate only a very small part of its thickness.

After one or more operations of refining, this crust must be removed, and fused in a furnace in contact with fuel, in order to obtain the lead. This process will be as easy as the reduction of that metal contained in the ashes of common cupells, and in a much smaller quantity. More litharge then will be obtained by the new method than the old; which is an advantage, as I have already observed. I shall here add, that as the sole of sand does not absorb so much oxyd of lead as that of ashes, it will not carry with it so much silver; for it is well known that lead revived from its ashes always contains more than that which arises from the reduction of litharge.

Instead of sand, argillaceous earth might be employed for the construction of cupells, as is the case in regard to the soles of the reverberating furnaces in the ci-devant Brittany; but it would be necessary to ram this earth repeatedly for several days; otherwise it would split, and these cracks would increase by the shrinking which must result from the heat, and lead would insinuate itself into these fissures: an inconvenience which cannot take place with sand even a little earthy. I shall observe also, that a

sole of earth would harden too much to allow a gutter to be dug for the passage of the litharge: in this case it would be necessary that the place destined for the oxyd to run off should be constructed with sand or lixiviated ashes.

I shall add also, that it will be advantageous to employ two kinds of sand in the formation of the bason of the cupell; one kind fine like that used by founders, and the other coarser and not earthy: the latter will form the first stratum, which, after being beat with rammers destined for that purpose, ought to be about three inches and a half in thickness. The fine sand, a little earthy, must then be applied over this first stratum to form a second, which is to be rammed like the former. Both these kinds of sand must be somewhat moistened before they are introduced into the furnace, in order that they may be better heaped up, and be consolidated by the rammers.

The sand of the lower stratum, being coarser than that of the upper, will absorb the moisture of the latter in proportion as it evaporates; and it will pass without any obstacle through the canals disposed for that purpose.

The lower stratum of sand may remain in its place when a new cupell is to be constructed with fine sand, and the part of the latter, which has not been impregnated with oxyd, must be mixed with new sand to form a cupell. Care must be taken in raising this sand not to touch the lower stratum; for the sand of the latter, which is coarse, must not be mixed with the other. This inconvenience may be avoided by beating over the bed of coarse sand a thin stratum of ashes, at which you must stop in removing the fine sand of the upper stratum.

It has been said that the founders' sand must be somewhat earthy, and that, if it is not, a little argil must be added to give it cohesion: but, as it is necessary that this

argil should be uniformly diffused through all the parts of the sand, it must be diluted in the water with which the sand is moistened, and the whole must be carefully mixed.

It may be objected, that as cupells of sand do not absorb so much litharge as those of ashes, more time will be required to terminate the operation of refining; since, in the new process, the oxyd, instead of being absorbed, ought to flow from the furnace. This circumstance needs excite no uneasiness; for the wind of the bellows, if well directed will make the litharge flow along the gutter more abundantly than if there had been an absorption.

I have seen refiners in Germany, who, in constructing their cupells of ashes, formed in the middle of it a small circular depression the diameter of which was proportioned to the quantity of the silver which they knew to be contained in the lead subjected to the operation. By this excellent disposition no grains of that valuable metal remain insulated from the cake; the whole runs into the central bason, and forms a cake perfectly round. I would recommend this practice.

I am certain that the cupells here proposed, if carefully and properly constructed, will be attended with complete success; will be free from the inconveniences of those of ashes, and at the same time will be economical. I am desirous, for the benefit of metallurgy, that the method here pointed out may be put in practice; it will prove that we ought not to be too tenacious in adhering servilely to ancient usages or to the common routine of workmen.—14 *Philos. Mag.* 210.

Acetite of Lead. There are two acetous salts of lead: one wherein the vinegar is saturated, which is Goulard's extract of saturn, the quack medicine (though a good one) commonly used to apply to inflammations, burns and

scalds, and bruises. It is this last only, which is the chemical test of the presence of mucilage and gum: whereon see Dr. Bostock's paper in 11 Nicholson's Journal, p. 75. This saturated salt of lead, Goulard's extract, or the aqua lythargyri acetati, contains lead 21, acetite acid 5, oxygen 2,1, water 71,9: whereas the sugar of lead or acetite of lead of commerce contains in 100 parts, lead 15,3, acetite acid 7,5, oxygen 1,5, water 75,7.

Take the corroded lead scraped off the blue lead in the manufacture of white lead: dissolve this in strong, clear, well-fined, colourless vinegar. If it be not so, it must be made so by distillation. A moderate heat will assist the solution; but if heat be applied, it should be in close vessels. The vessels should be of glass or earthen ware; (or perhaps tin might answer). The vinegar should not be quite saturated. The solution should slightly redden litmus paper. Draw off the solution quite clear. Crystallize by slow evaporation. If the crystals be not perfect, dissolve the crystallized mass over again in distilled vinegar, which I believe the Dutch always use.

I fancy the first washings of the white lead in the white lead manufactory, may be worth saving and evaporating, where the intent is to make sugar of lead.

This I believe to be the process: but I am not confident of the accuracy of my information. In my time it was not made in England: it was entirely imported from Holland. The calico printers used it in very large quanties to make printers mordant, the acetite of alumine. This is made by mixing from one part to one part and a half of sugar of lead in saturated solution, with a saturated solution of one part of ground alum. The alum must be previously tried to see whether it contain iron: if it do, it will turn the madder red of a chocolate hue.

I have already suggested, that the acetite of lime, made

by dissolving whiting or chalk in strong vinegar, well fined, may be substituted for sugar of lead.

Sugar of lead, is coming greatly into fashion in doses of from one to three grains, in cases of hemorrhage of almost every species.

It has been proposed to substitute the pyroligneous acid for vinegar, and it may be done; but whether it may be done as cheaply as by making vinegar out of cyder, or whiskey and sugar, I cannot say. The Messrs. Mollerats (Freres) at Paris, some years ago, presented a memoir to the institute, in which they announced the making of strong vinegar from the pyroligneous acid, or the acid distilled from wood. It had the pungent smell of radical vinegar: one pint would make a gallon of vinegar of ordinary strength, very clear, very pure, and very pleasant. I know not the process. Dr. Bollman has made it in small quantities perfectly well. I have made it, not quite free from empyreuma, in the making of carburetted hydrogen as a gas-light from wood, before my class. The acid liquor that comes over when the wood is distilled being percolated through charcoal, then saturated with chalk, again percolated, and the acetite of lime so produced distilled with sulphuric acid, will produce a pyroligneous acid, which however still retains more empyreuma, than can be borne to be used in cookery.

The empyreuma perhaps would be of no consequence in making a rough and impure sugar of lead for calico printers, any more than when it is used by them to make the pyrolignite of iron, for their blacks. But concerning all this I know little experimentally. It is a subject worth pursuing.

Patent Mineral Yellow. The fused muriat of lead, produced by decomposing common salt by means of litharge; triturating it in the form of a thin paste with

water for twelve or fourteen hours; washing away the soda; and drying and fusing the white muriat, I have already mentioned under the head of white lead a few pages back; I shall therefore say no more about it. Turner's patent was taken out February 26, 1780. It was set aside in 1787. See Turner v. Winter, 1 Durn. and East, 602.

But as the method of making it in this country, appears to me to be an improvement, I shall give it. I am obliged for the process to Dr. Hunter.

Take 66 lbs. litharge, and one bushel of salt: (by the way I would remark, that one bushel of Lake or Genesee salt, of Liverpool fine, and of Norwich fine, will weigh but 56 lbs.: a bushel of Liverpool salt, second fine, lightly put into the measure and not pressed down, will weigh 61 lbs.: a bushel of St. Ubes' salt in like manner, will weigh 76 lbs.: of Turk's island salt from 83 to 84 lbs.: All this I have tried myself, T. C.) Dissolve the salt in a pan. When dissolved, strain it and pour back the liquor into the pan: then add the litharge, keep a strong fire under the pan for three hours, until the mixture be perfectly white. The liquor then is caustic mineral alkali, which must be poured off and preserved. Then wash off the alkali that remains in the sediment by repeated waters, adding it to the liquor poured off. Take the sediment, which is a muriat of lead; dry it on chalk stones; when dry, put it in crucibles half filled, and melt the substance in an air furnace. The crucible should be covered, for any carbonaceous matter will reduce the muriat into metallic lead. It should remain in the furnace till cold, to preserve its crystallized form.

Sheet Lead Boxes. These are convenient in many respects for the keeping of substances, that require to be preserved from air and moisture. But as it does not seem

to me a business of much importance, I shall only refer to the method of making these boxes, in No. 2. of vol. 1. p. 133, for July, 1802, of the New Series of the Repertory of Arts.

Shot. Is made by melting lead with arsenic, and pouring it out of Troughs from a great height into a large vessel of water. The height is intended to give rotundity to the shot: the arsenic to make it more fusible, so that it shall preserve its rotundity arising from its liquid state until the moment when it is required to be condensed. Mr. Paul Beck's shot manufactory at Philadelphia, is, I believe, 175 or 180 feet high. The first fall for small shot is about 130 feet, the second fall or melting place, is about 170 feet high.

I give below the common English processes: but in my opinion the practice is, to melt the whole quantity of arsenic, with a small portion of the lead first: and then to add this strongly arseniated lead to the unalloyed lead, when the latter is melted. The arsenic, *should not be orpiment.* It should be white arsenic. It should be mixed with three or four times its bulk of charcoal, lamp-black, rosin, or some carbonaceous or inflammable substance, and being tightly inclosed in several folds of paper, should be thrust down with a stick to the bottom of the lead. The pan of melted lead, should be then covered, in order to aid the impregnation of the lead with the arsenic. The pan should be of thin cast or thick sheet iron; for the heat must not be too great. It is right, when the surface of the lead is irridescent.

As the general method of making shot is kept a secret, I give all the processes I have.

Patent Milled Shot, is thus made; sheets of lead, whose thickness corresponds with the size of the shot re-

quired, are cut into small pieces, or cubes, of the form of a die. A great quantity of these little cubes are put into a large hollow iron cylinder, which is mounted horizontally and turned by a winch; when by their friction against one another, and against the sides of the cylinder, they are rendered perfectly round and very smooth. The other patent-shot is cast in moulds, in the same way as bullets are.

Common Small Shot, or that used for fowling, should be well sized; for, should it be too great, then it flies thin and scatters too much; or if too small, then it has not weight and strength to penetrate far, and the bird is apt to fly away with it. In order, therefore, to have it suitable to the occasion, it not being always to be had in every place fit for the purpose, we shall set down the true method of making all sorts and sizes under the name of mould-shot, formerly made after the following process:

Take any quantity of lead you think fit, and melt it down in an iron vessel: and as it melts keep it stirring with an iron ladle, skimming off all impurities whatsoever that may arise at top; when it begins to look of a greenish colour, strew on it as much auripigmentum or yellow orpiment, finely powdered, as will lie on a shilling, to every twelve or fourteen pounds of lead; then stirring them together, the orpiment will flame. The ladle should have a notch on one side of the brim, for more easily pouring out the lead; the ladle must remain in the melted lead, that its heat may be the same with that of the lead, to prevent inconveniences which otherwise might happen by its being either too hot or too cold; then, to try your lead, drop a little of it into water, and if the drops prove round, then the lead is of a proper heat; if otherwise, and the shot have tails, then add more orpiment to increase the heat, till it is found sufficient.

Then take a plate of copper, about the size of a trencher, which must be made with a hollowness in the middle, about three inches compass, within which must be bored about 40 holes according to the size of the shot which you intend to cast: the hollow bottom should be thin; but the thicker the brim, the better it will retain the heat. Place this plate on a frame of iron, over a tube or vessel of water, about four inches from the water, and spread burning coals on the plate, to keep the lead melted upon it; then take some lead and pour it gently on the coals on the plate, and it will make its way through the holes into the water, and form itself into shot; do thus till all your lead is run through the holes of the plate, taking care, by keeping your coals alive, that the lead does not cool, and so stop up the holes.

While you are casting in this manner, another person with another ladle may catch some of the shot, placing the ladle four or five inches underneath the plate in the water, by which means you will see if they are defective, and rectify them. Your chief care is to keep the lead in a just degree of heat, that it shall be not so cold as to stop up the holes in your plate, nor so hot as to cause the shot to crack; to remedy the heat, you must refrain working till it is of a proper coolness; and to remedy the coolness of your lead and plate, you must blow your fire; observing, that the cooler your lead is, the larger will be your shot; as, the hotter it is, the smaller they will be.

After you have done casting, take them out of the water, and dry them over the fire with a gentle heat, stirring them continually that they do not melt; when dry, you are to separate the great shot from the small, by the help of a sieve made for that purpose, according to their several sizes. But those who would have very large shot, make the lead trickle with a stick out of the ladle into the water, without the plate. If it stops on the plate, and yet

the plate is not too cool, give but the plate a little knock, and it will run again; care must be had that none of your implements are greasy, oily, or the like; and when the shot, being separated, are found too large or too small for your purpose, or otherwise imperfect, they will serve again at the next operation.

Shot, tin-case, in artillery, is formed by putting a great quantity of small iron shot into a tin cylindrical box called a cannister, that just fits the bore of the gun. Leaden bullets are sometimes used in the same manner; and it must be observed, that whatever number or sizes of the shots are used, they must weigh with their cases nearly as much as the shot of the piece. [*Greg. Entyclo.* 665.

Lead, how formed into shot. Lead is employed in considerable quantities in the casting of shot, for which a patent was granted in 1782, to Mr. William Watts, in consequence of his invention for granulating lead, solid throughout, without those imperfections which other kinds of shot usually present on their surface. The patentee directs 20 cwt. of soft pig-lead to be melted in an iron pot, round the edge of which, a peck of coal-ashes is to be strewed upon the surface of the metal, so as to leave the middle of the latter exposed. Forty pounds of arsenic are next to be added to the uncovered lead, and the pot closely shut; the edges of the lid being carefully luted with mortar, clay, or other cement, in order to prevent the evaporation of the arsenic. A brisk fire is then kindled, so that the two substances may be properly incorporated; when the metal ought to be skimmed and laded into moulds, that it may cool in the form of ingots or bars, which, when cold, are called *slag*, or poisoned metal—20 cwt. of soft pig-lead, (according to the quantity of shot intended to be manufactured) are next to be melted in the manner above directed; and, when it is completely lique-

fied, one of the ingots or bars of slag must be added: as soon as the whole is combined, a small quantity of the liquid metal is to be taken out with a ladle, and dropped from a height of about two feet into the water. If the shot be not perfectly round, it will be necessary to add more slag, till it drops in a globular form. The metal is next skimmed, and the scum poured into an iron or copper frame perforated with round holes, according to the size of the shot designed; the scum is then to be squeezed while soft, through the frame, into which the liquid should be poured, and dropped through the holes. For the smallest shot, the frame must be at least ten feet above the water, and for the largest, about 150 feet; the height being increased or diminished, in proportion to the size of the shot. [1 *Art. Man.*

Shot Manufactories have lately been established or revived, and appear to promise to supersede the importation of English shot. They are manufactured principally from Lead found in Louisiana, and shipped from New-Orleans.

Patent shot, as Dr. Black has informed us, are manufactured in England as follows:

A little orpiment or arsenic is added to the lead, which disposes it to run into spherical drops much more rapidly than it would do when pure. The melted lead is poured into a cylinder, whose circumference is pierced with holes. The lead streaming through the holes soon divides into drops, which fall into water, where they congeal. They are far from being all spherical, many being shaped like pears, and must be picked. This is done by a very ingenious contrivance. The whole is sifted on the upper end of a long, smooth, inclined plane, and the grains roll down to the lower end. But the pear-like shape of the bad grains makes them roll down irregularly, and they

waddle as it were, to a side; while the round ones run straight down. They are received into a sort of funnel, which extends from the one side of the inclined plane to the other, and is divided by several partitions, so that it is really the mouth of several funnels, which lead to different boxes. Those in the middle receive the round grains. [2 *Art. Man.*

The shot when made, is separated into sizes by means of sieves, whose wires are set according to the different sizes required. The shot is glazed by putting them into a barrel and turning it round, till by the friction and attrition they become perfectly round, smooth and shining.

I believe in this country, the proportion of arsenic is nearly as follows. About 7 lb. of arsenic is first added to about five hundred weight of the metal. Then of this mixture, so much is taken to add to the fresh lead, as will make the proportion of arsenic about 2 1-2 or 3 lbs. to the ton. Of this about one half a pound will evaporate. Compare this with the English patent proportions above given.

In the Louisiana country, shot manufactories are established, where the shot is made by letting the lead fall from the top to the bottom of the bank of the Mississippi, at low water: so that the enormous expence of such a building as that in Philadelphia, is saved. T. C.

To ascertain the quantity of whiting in white lead.

Take a specimen of flake white which is generally pure white lead, an ounce for instance: mix it with twice its bulk of lamp-black, or with oil, or with rosin: fuse it, and the instant it is fused, take it off the fire, let it cool and weigh it. You may fuse it in a small crucible or even in a tobacco-pipe, stopping the hole inside with a small piece of the tobacco-pipe. Then treat in like manner the lead you wish to try: The difference in weight

will be the adulteration. This process may be checked thus. Take the scoria of the last mentioned fusion; dissolve it in muriatic acid or nitric acid: filter it: precipitate it by carbonat of potash (a solution of pearl ash): wash and dry the precipitate, which will be a carbonat of lime, or whiting. The weight gives the quantity of whiting wherewith the lead was mixed.

Or, dissolve the lead you suspect in nitric acid; precipitate by well made, saturated, prussiat of potash, or prussiat of lime. The prussic acid will throw down the lead only. This may be washed, and melted with any reducing flux. If prussiat of potash be used, precipitate the remaining solution by carbonat of potash, which will throw down the carbonat of lime, which being washed, dried and weighed, will give the weight of the adulteration.

Or, dissolve the lead suspected in nitric acid: precipitate with a solution of sulphuret of lime. This will throw down only the lead.

Or, dissolve in nitric acid; and precipitate with chromat of pot-ash, which will not decompose nitrat of lime.

Chromat of Lead. This beautiful colour may be made thus.

In the vicinity of Baltimore and Philadelphia, the Granite and the Gneiss of the primitive strata, are succeeded by Steatite and Amphibole: these two last appear to be somewhat intermingled (but not in the same stone): to these as a stratum, succeeds the granular or crystallized primitive limestone, which, near Philadelphia, is the marble of White Marsh. Between the limestone and the steatite, but enveloped in steatite, in Chester county about twelve miles from Philadelphia, and at the Bare hills about nine miles from Baltimore, is found a chromated iron. When this pounded fine, and treated for an hour in a

strong red heat with three fourths of its weight of clean pure nitre, the nitric acid is decomposed, the chrome is acidified, and then combines with the alkaline base of the nitre, forming a chromat of potash. To obtain this pure, the solution must be repeatedly crystallized to get rid of a small portion of iron, which will gradually fall down in an oxyd; the other impurities, such as the earths that might have been taken up in small quantities, will also fall down. The solution after two or three crystallizations will then contain nothing but chromat of potash, together with a small quantity of nitric, or uncombined alkali; this can be ascertained by an intermixture of white with the yellow precipitate of lead; and can be obviated by a small quantity of nitric acid. When the chromat of potash is concentrated, and added to a solution of nitrat or even acetat of lead, (which need not be religiously saturated with metal) a yellow precipitate will fall down, which is the yellow chromat of lead. The chromat of potash will throw down nitrat of mercury a deep orange colour.

Naples Yellow. This ought to be a natural production found near Naples; a kind of lava, unchangeable by fire and by acids. The artificial kind is thus made. Take 12 ounces of pure white lead, and 2 ounces of washed calx of antimony; the common diaphoretic antimony of the shops; half an ounce of calcined Roman alum, which is generally free from any admixture of iron, and one ounce of sal ammoniac. Pound them well together, and put them in an earthen crucible with a cover. Keep them in a low red heat for three hours. If you want, the mixture more of a gold colour, add a quarter of an ounce more of antimony, and as much sal ammoniac. Do not let any iron touch this colour.

For patents relating to white lead see Repertory of Arts, Old Series, vol. 3. p. 225, vol. 5. p. 249, vol. 8. p. 378, vol. 11. p. 38. New Series, vol. 6. p. 169, vol. 7. p. 399. For the manufacture of sheet lead, see Repertory of Arts, New Series, vol. 1. p. 133. For refining lead, Ib. New Series, vol. 2. p. 72, vol. 4. p. 194. T. C.

MORTAR.

On the Cement used in building, called Mortar. (By the Editor.)

Having finished the article Bricks, I proceed to that of mortar.

Limestone, when subjected to chemical experiment, is found to contain from 43 to 44 per cent. of carbonic acid gas, formerly called fixed air. It contains also a small quantity of water. When pure limestone is burnt in a lime-kiln in the best manner, one ton, or twenty hundred weight of 112 lb. to the hundred weight, will yield, about 11 1-4 hundred weight of good lime. The loss is, partly water; but chiefly carbonic acid gas. (Watson.)

A bushel of chalk will weigh 86 1-2 lb. A bushel of lime made from that chalk weighed when warm from the kiln, 66 1-4 lb. which is greatly too much: for a ton of the same chalk when *well* burnt, produced but 11 cwt. 1 qr. 19 lb. of lime. If burnt in the best manner, it ought not to produce more than 11 cwt. of lime. Ib.

A hard limestone from Lancashire weighed 184 lb. to the bushel, up-heaped. At Clitheroe in Lancashire the limestone up-heaped, weighs 147 lb. to the bushel. If the produce be more than 11 hundred weight or thereabout from the ton, either the limestone is impure, or the

burning is deficient, in fuel or in time. The burning ought to continue in a strong red, approaching to a white heat for at least ten hours.

Lime exposed to the air for about twenty days will be reconverted into limestone, and become perfectly useless as a cement. Dr. Watson converted into lime 540 grains of statuary marble: the lime weighed 304 grains: from the 10th of February to the 4th of March, it had gained so much in weight, that it weighed 515 grains. Dr. Higgins exposed 2 lb. of well burnt, non-effervescent chalk lime, to the air for 22 days; at which time it weighed 3 lb. 2 ounces and 1 drachm and a half. The greatest proportion of this accession of weight, is gained in the first 4 or 5 days.

This encrease of weight is owing to 1st. carbonic acid gas imbibed from the atmosphere: 2d. in smaller proportion, to water imbibed from the atmosphere. These substances thus imbibed, reconvert the lime into limestone. So that mortar made from such lime, might as well be made from powdered limestone. It is no cement: it produces no cohesion.

The deeper and more circular, is the heap of lime, the better is the inner part protected from the bad effects of the atmosphere. The external surface is spoiled first. If the lime be slacked, and made into a paste with lime-water, (water wherein some lime has been previously slacked) and protected by boards, on all sides and on the top, it may be kept for a long time tolerably well. Or if slacked into powder immediately on being brought from the kiln, and made up into a compact heap.

If lime from the kiln effervesces, or gives out air (carbonic acid gas) on being dissolved in muriatic or nitric acid, it is ill-burnt in proportion exactly to the quantity of this air which it yields.

Lime ought to be brought from the kiln, in a cart covered with boards.

It ought not to be brought in rainy weather. I have twice or thrice seen carts set on fire by this means. It ought to be kept in a dry place, with the precautions before mentioned. The neat rule is, expose it to the air as little as possible.

When the limestone is so good, and the burning is so complete, that twenty parts of limestone is fairly burnt into eleven parts of lime, which it can be and ought to be—then will such lime, used as recently as possible, require seven parts of sand to one of lime, to make the best mortar. It will require less sand in proportion as it is badly burnt, or by negligent exposure reconverted into limestone.

Nothing is required, to make the best mortar for building, but good lime and good sand.

No sand is good that contains any clay. It should be washed out.

No sand is good, that is rounded by attrition.

The best sand is quartzose, having flat sides and angles.

The best mixture of such sand, is half somewhat coarse, half fine: not too fine, for ground or powdered quartz, or flint may do for stucco, but not for mortar: the flat sides and angles are destroyed by the pulverization.

The theory of mortar appears to me to be this. Water is added, to enable the lime to crystallize, and to attract carbonic acid from the atmosphere. This is done gradually. If left quietly and undisturbed, to regain this gas from the atmosphere, the mortar crystallizes into limestone, and unites by the attraction of crystallization to the sides of the quartzose sand, best calculated to afford the strongest union or adhesion. The attraction is threefold, 1st. that of crystallization: 2d. that of chemical or elective attraction in the moist way; and 3d. the com-

mon attraction of aggregation or cohesion. I conceive each of these to be distinct.

Hence it is essential to good mortar, 1st. that the lime be burnt so as to reduce twenty parts by weight to eleven parts. 2d. That it be used as quickly as possible. 3d. That if it cannot be used quickly, it should be packed up when slacked in the smallest possible compass, and covered from the contact of successive changes of air. 4th. That to fresh lime, seven parts of sand are not too much: lime half burnt will not cement more than three parts. Hence the threefold extravagance of not using lime in a proper state: the lime is wasted: the weight of carriage is increased by hauling limestone instead of lime: and more lime is required to the same quantity of sand.

Though not essential to good building, it is very nearly so, that the brick (always supposed to be well burnt) should be dipt in lime water the instant before it is laid. The dust on a dry brick effectually prevents the adhesion of the mortar; and the brick also absorbs so much of the moisture of the mortar, that enough is not left to enable it perfectly to crystallize. Immersing the brick in lime water, makes it also less liable to imbibe moisture. It forms an impregnation of limestone.

When the lime is good, no addition of skimmed milk, animal gelly, oil, or resinous substances, or any other, contributes to the goodness of the mortar: good lime, good sand, are the only requisites.

The putting beams and rafters, or any other method of shaking the wall, and greatly disturbing the crystallization of the mortar while damp, injures its power as a cement.

In countries where limestone and fuel are plenty, and labour cheap, the ancient method of building walls by *grouting*, may be eligible. It is this:

The foundation being dug out the required width in proportion to the thickness of the wall, a strong frame of boards was placed on each side. The space between the boards filled up with any kind of stone most convenient and at hand, thrown in promiscuously. The interstices of large stones, were roughly filled in with smaller ones. Mortar made from fresh burnt lime and fine sand, being made into a paste sufficiently thin to be poured, was poured in upon the loose stones, and thus filled up every crack and crevice. In a few hours, the boards were moved forward to form a caisson for another part of the wall, and the joints of the stones where the grouting had exuded, were trimmed off. Many of the strongest and most durable of the very old buildings in England, were manifestly so constructed.

Where work is intended to be solid and substantial, grouting at every course is indispensable. It is indispensable also in all arch work: in England it is never omitted in arches. It never ought to be omitted in such cases, or in cut groin-work.

Brickwork in cellar walls, or cellar arches, never dries if the mortar be not good, and used fresh, before it has become effete.

All these remarks are still more essential in the building of public works, as fortifications, than in private dwellings. By attending to these directions, a wall of equal thickness will have more than double the strength it usually has, built in a common way: and the mortar or cement, moreover, will harden incomparably sooner. Water used to make a paste of pounded limestone (common mortar) and sand, can only be gotten rid of, from the middle of a thick wall by the slow evaporation of many years: but if the lime be really lime, and well and recently burnt, all the water even of grouting, is rapidly consumed as water of crystallization.

For *Stucco*, bone ashes well burnt and sifted, in the proportion of from one half to one fourth of the lime, is an addition useful to prevent the cement from cracking, without impairing its other good qualities; and this whether for inside or outside work. For the latter the proportion ought not to be of bone ashes more than one fourth.

The method of making bone ashes is as follows: I take it from page 172 of Higgins on Cements.

"I will premise a sketch of the most profitable processes by which they are prepared, at a moderate price not much exceeding that of good stone lime.

The bones collected in great cities, are broken to small fragments in a mill, and boiled in water, in order to extricate and save the oil of them. They are then put into a large iron still, through an aperture which is stopped up closely after the charge is made. The still, which opens into an apparatus of refrigeratory vessels, is heated gradually to redness, until all the volatile alkali, commonly called spirit and salt of hartshorn, is expelled from them, together with empyreumatic oil, water, and certain elastic invisible fluids: the alkali, being the only valuable article amongst these, is retained and condensed in the refrigeratory tubes and vessels with all possible care, whilst the elastic fluids, lest they should burst the vessels, are suffered to escape in places distant from the fire or the flame of candles, because they are combustible, and if they catch fire whilst air remains in the condensing vessels, explode like gunpowder.

The bones thus heated without being exposed to the air, are charred to blackness, but still remain combustible. When they are required in this state, the iron still is kept closed until they cool, and then the blackest of them are ground to fine powder, which is used as a sub-

stitute for ivory black, which is prepared in the same way from ivory. The coarser powder of these, is what I understand by powder of charred bones. But when this is not the manufacturer's design, the door of the iron still is opened whilst it is hot, and the charred bones which flame and burn when they meet the air, are thrown into a kind of kiln, at the bottom of which the air can freely enter, and maintain the combustion, until the bones are burned to whiteness, for the greater part. The white fragments are picked, and rather bruised, than ground, to a gritty powder, by a millstone which rolls on them vertically over an inclined circular plane. This powder passed through a sieve is called bone-ashes, which are much used in metallurgy, and fitter for our purposes in incrustations, than the powder of burned bones ground as pigments are. The fragments which have not been thoroughly burned in the kiln, form a dark grey powder; and mixtures of the white and grey burned bones afford bone-ashes of the lighter grey colours.

The whole quantity of bone-ashes, which is to be used in the same incrustation, ought to be well mixed; for it is impossible to sort the well burned or the grey bones so accurately as to secure an unity of colour in the parcels of powder which are successively prepared, and a very small variation of colour will be seen in the incrustation."

Water Cement, is made on the continent by mixing with good mortar, the ochry earth Puzzuolana, or a similar earth called Traas or Terras in England, where it is imported from Holland. It is mixed accurately with the mortar in proportion of about one third or one fourth of the lime. It is obvious that if precautions are necessary in any case to secure good and perfect lime, they will be necessary in the case of water cement.

I believe that the same proportion of almost any oxyd of iron, or of manganese, or even of the common smithy-slack of a blacksmith's shop, well sifted, will answer the same purpose. So will Basalt, burnt and ground.

Loriot's patent for water cement, consists alone in the mixing of ground fresh burnt lime with common mortar, which is manifestly imperfect and unscientific; inasmuch as old effete mortar, can never be equal to fine quartzose sand.

Higgins's patent stucco, is fresh, well-burnt lime one part; sand half fine, and half rather coarser, well washed from dirt and clay, six or seven parts; I think six parts best. Bone-ashes ground tolerably fine, equal to one fourth of the lime. The water used must be lime water. For inside work the bone-ash may be in proportion of a third of the lime.

Johnson's patent stucco, was characterized merely by an admixture of blood with the water used to make up the cement.

I regard Higgins's as the best. I have seen them, all both fresh used, and many years afterward. T. C.

PERKIN'S IMPROVEMENT ON WATER MILLS.

WITH A PLATE.

THE subscriber has recently obtained a patent for an improvement in water-mills, which, from actual experience, has been found to be of great importance; it consists in the complete removal of all the inconveniences heretofore experienced from back water.

It is a well known fact, that in most situations it has been found necessary to place water-wheels from one to three feet higher than they would be, were it not requisite to avoid the back water, occasioned by the freshets and high tides. In nearly all cases

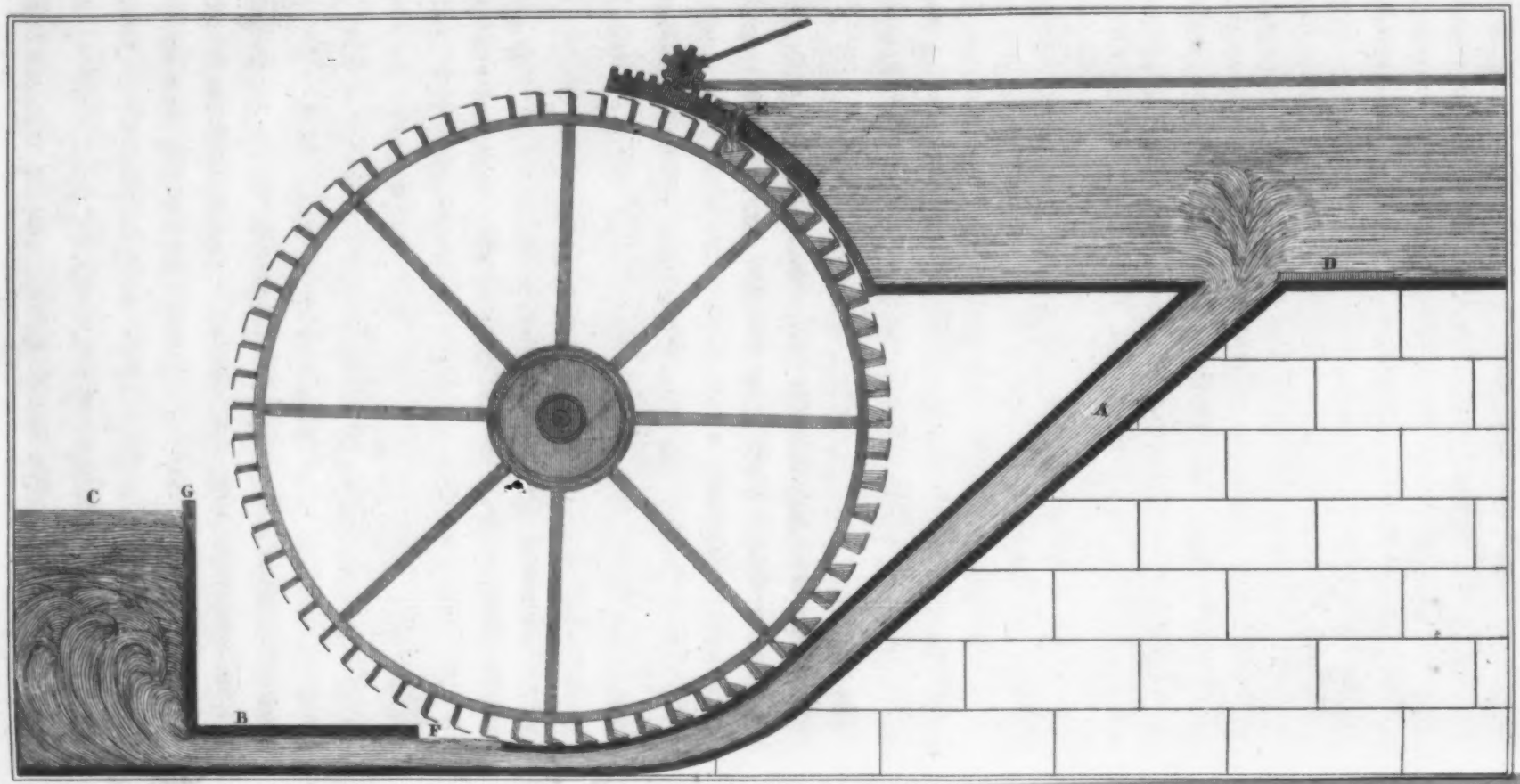
there is a serious loss of power, but more especially so where it consists of a few feet only. The patentee has satisfactorily proved, that with a head and fall of twelve feet, six feet of back water may be driven away, and with it, all the water which has been expended in moving the wheel: there is therefore, no exaggeration in declaring, that taking into the account the time that many mills are stopped by back water, and the permanent loss of power from the height at which the wheels are hung in order to avoid this difficulty; from one fifth to one third of the power is absolutely lost, an evil which is completely obviated by this invention.

All the time when the wheel is retarded by back water, a large quantity is constantly running to waste; this invention accomplishes its removal by the application of a portion of this superabundant water, which would otherwise run over the dam.

The above section will shew the operation of this principle in removing back water. The construction of the floom, and raceway, differs from the common form, by having a tight tube, A, running from the bottom of the floom, as at D, to or past the centre of the bottom of the wheel, and of about four times the size of one which would be necessary to turn the wheel. The size of the tube may vary according to the back water common to the mill. The lower end of the main tube, A, being in a direct line to that of the horizontal tube, B, will direct the water which rushes down the former through the latter, and at the same time overcome the pressure of the water and atmosphere at C, so that the atmosphere may act upon the back water which had collected round the bottom of the wheel, and force it through the tube, B, which being one third larger than tube A, will admit enough of the back water at the opening, F, to fill the tube B, and thereby in a few minutes, to entirely remove it from the bottom of the wheel; and the water which has been expended in moving the wheel, will join the current at F, and pass off through the tube B. The bulk-head, G, must rise above the extreme height of the back water, for as there is no other passage for the water to escape from the wheel, than through the tube B, there should be no other through which, in times of back water, it can pass to the wheel. When the freshet is over, and the water has found its lowest level, the horizontal gate, D, should be shut, and the water which carries the wheel will run off through the tube B.

This method of removing back water, will not apply to tide mills, except where there is a great surplus of water; in that case, by adopting this plan, the mill may be made to go sooner and later

M.r Jacob Perkins's Improvement in Mills for the purpose of removing Back Water.



than it otherwise would. Where the tide rises at the tail of a common mill, this principle may be applied to great advantage, as the wheel in many situations, may be set two or three feet lower than it commonly is, and by driving off the back water occasioned by the tide, the extra power which is gained by increasing the fall, will be much more than the loss of the water expended in drawing off the back water at high tide.

Communications upon the subject of this improvement will be gratefully received, and immediately noticed by the subscriber, the patentee, of Newburyport, Massachusetts, or by Dr. Thomas P. Jones, Philadelphia.

JACOB PERKINS.

STEAM ENGINE BOILER,

WITH A PLATE.

Sir—As steam engines are becoming much in use throughout the United States, every thing that will tend to their improvement in working, or in saving of fuel, ought to be made public. With this view I have taken the liberty of making a rough sketch of one of the boilers which has been in use upwards of ten years at the water works in Philadelphia, for your inspection. After giving every attention in ascertaining the effect of three different sorts of boilers in that work, for several years, I am fully persuaded, that it far exceeds any boiler now in use at the water works, or any other which has come under my notice, both in saving fuel and the ease with which the steam can be kept up. This boiler is, and always has been, defective, by its having a wooden case, which cannot be kept sufficiently tight; and, with this great defect, it does not burn so much fuel as the others with cast iron cases, which have the fire under their bottoms, with flues passing through and around them. The present drawing contemplates a cast iron case, which would be durable, and, no doubt, last fifty or sixty years, as it is not exposed to the heat of the fire. *However, an objection may be made to its expense*, I am well persuaded that if those who have engines built, knew the value of a boiler of this sort, 50 per cent. advance in the first cost would be no object to them, as they would save far more than the difference long before the boiler would be worn out.

With a view that the plan of this boiler should be submitted to the citizens of the United States who wish to embark in steam engine machinery, I hand it to you to decide whether it is worth a place in your work now publishing or not.

With great respect,

FREDERICK GRAFF,

Superintendant of the Philadelphia water works.

THOMAS COOPER, Esq.

The plan is drawn to a quarter of an inch to the foot.

The perpendicular heater A, may be raised in size and situation to suit the idea of the builder.

The dotted lines in plan B, represents the flues C, above the fire bed, and which pass out of the boiler into the stack, at the mouth of which the damper is fixed.

D, the fire grates.

E, the door way, which can be so arranged, if required, to consume the smoke by lowering the fire bars or grates.

F, the water line six inches above the flue.

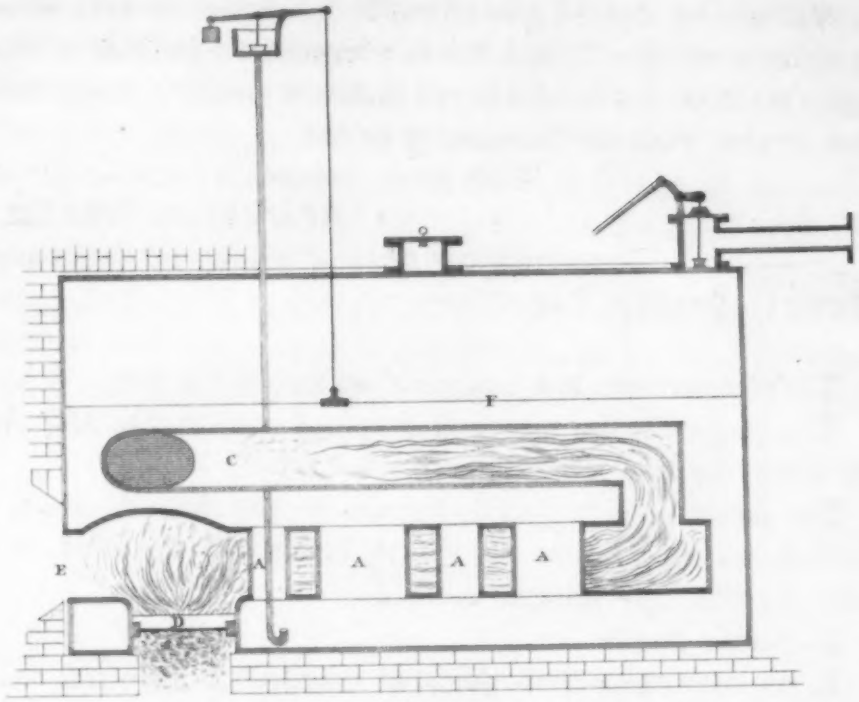
G, a section through the fire place, showing the front range of perpendicular heaters and the horizontal flues above, with coal grate and ash pit.

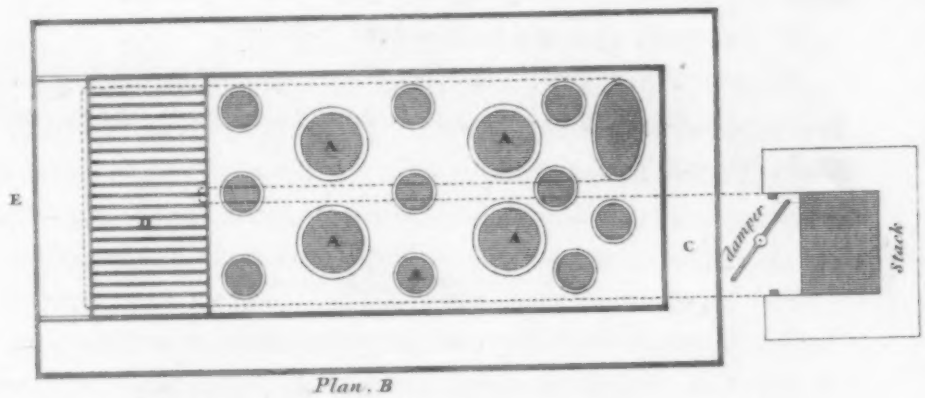
STATISTICS. BY THE EDITOR.

Eight grain gallons of 268,8 cubic inches to the gallon make one Winchester bushel of grain; struck, that is even with the surface. The bushel ought to contain 2150,42 cubic inches: it ought to be 18,5 inches diameter throughout and eight inches deep. In England it is well settled as an indictable offence to buy or sell by any other bushel: I strongly incline to think, that it is indictable to buy or sell by any other bushel, here also: for I know of no other legal bushel.

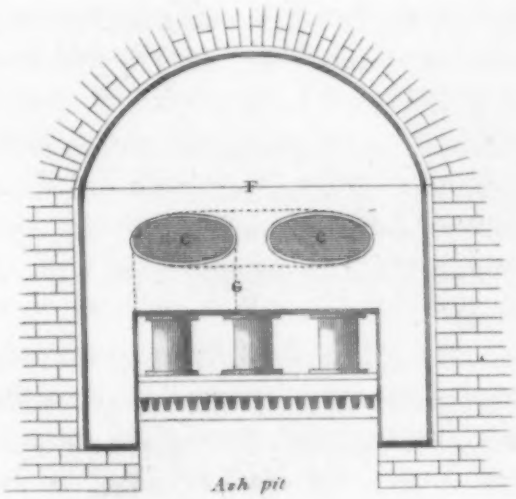
Retailers in this country, generally sell every commodity whatever by the wine gallon of 231 cubic inches, without regard to the measure by which they purchase. Malt liquor is sold in England by the ale gallon of 282 cubic inches, being to the wine gallon, as one pound avoirdupois is to one pound troy. It is high time we

Boiler at the water works, Philadelphia.





Plan. B



H.Anderson sc.

had a common standard of weight and measure in this country. The want of it is a sad reflection on our want of knowledge.

The peck loaf of England must weigh 17 lb. 6 oz.: for which about 14 lb. of flour is usually employed: the half peck weighs 8 lb. 11 oz.: the quartern loaf, 4 lb. 5 oz. 8 drs. Hence in the usual way of sale, 56 ounces of flour make 69 and a half ounces of bread; or 10 lb. of flour makes 12 1-2 lb. of bread.

The following facts were ascertained by direct experiment instituted for the purpose.

A Winchester bushel of good wheat weighing fifty-nine pounds, produced,

	lb.
Of the finest flour - -	28
Seconds - - - -	5 $\frac{5}{8}$
Fine middlings - - -	7
Coarse ditto - - -	3 $\frac{3}{8}$
Bran - - - -	15
The bushel - -	59

Also, 615 lb. of clean wheat was taken and ground: it produced 514 lb of flour, and 84 lb. of bran. The flour when baked produced 672 lb. of household bread, or at the rate of thirty per cent. beyond the weight of the flour. The salt, the yeast, and the wood employed to bake it, cost 5 shillings sterling: the workmanship 2s. 6d. I presume the bread was weighed while warm. This is at the rate of 13 lb. bread to 10 lb flour.

According to Lord Sheffield, the general calculation is, that a Winchester bushel of wheat weighing 60 lb. will produce 54 lb. of meal, 5 1-4 lb. of bran and three-fourths of a pound of water: and will make 68 lb. of bread: this is in the proportion of 13 1-3 lb. of bread for 10 lb. of flour. See vols. 26, 29, 35 of the Annals of Agriculture.

It appeared from the examination of the baker's about that period of scarcity in England, that American flour weight for weight produced rather more bread than the best English flour. Hence I conclude that 10 of American flour ought to make 13 of bread, if well managed.

The facts shew the great value in point of economy. 1st. In eating household bread, and 2d. In baking at home. The great art of baking, is in the laborious kneading of the dough. A small quantity of pearl-ash dissolved in the water, makes the bread somewhat lighter and assuredly wholesomer. All the bread used

in my family, is baked in a common ten-plate stove. I do not usually meet with better bread. I suspect the wheat of slaty upland, is heaviest and sweetest.

How much Land will supply a man with necessary Food.

I suppose a labouring man, sufficiently fed. Such a man will consume food of whatever kind it be, that will be equal in amount to one pound and a half of bread, one pound of meat, and half a pint of whiskey, per day. To which ought to be added, an allowance for fuel, pepper, salt, and a moderate proportion of vegetables. His dress will form another item: his habitation another.

One pound and a half of bread per day, will amount to 547 1-2 lb. of bread per year. At 13 lb. of bread to 10 lb. of flour, this will require 420 lb. of flour. If according to the experiment above related 615 pound of wheat will produce 514 lb. of flour, then 420 lb. of flour, will require 500 lb. of wheat. This at 60 pound to the bushel, will amount to eight bushels and one-third per annum. Allowing a little for indispensible loss and waste, this will be eight bushels and a half. In England the calculation is eight bushels annually, as the consumption of man, woman and child: and is near the truth. In this country we live more fully and less carefully.

I do not consider the average produce of an acre of wheat in the county of Cumberland, in Pennsylvania, which is a rich county of land, as more than 18 bushels per acre. The average produce of all England, is not less than 22 bushels of wheat per acre, when wheat is put in as a crop.

Since I have been at Carlisle, when flour has been at six dollars the barrel of 196 lb. net weight, wheat has been at $1 25 cents per bushel: butcher's meat six cents per pound: and whiskey by the quarter cask, at sixty cents per gallon.

	$	cents.
The grain required for one man per annum then will be 8 1-2 bushels at $ 1 25 cents	10	62 1-2
Meat, 365 lb. at 6 cents - - -	21	90
Whiskey 23 gallons, or allowing 2 gallons extra for harvest time 25 gallons	15	00
	47	52 1-2
Fuel, vegetables, pepper, salt, may fairly be considered as at least	7	47 1-2
	$ 55	00

It appears, that an acre of ground cultivated in wheat at 18 bushels per acre will yield 22 1-2 dollars in the market. But all the other articles are equally the produce of the soil. Hence if

one acre be required for 22 1-2 dollars worth of food, 55 dollars worth will require very nearly two acres and a half.

But where in good cultivation, a wheat crop cannot occur more than once in four years, interposing rye, oats, and clover, land that will produce eighteen bushels under usual culture, will not yield upon the average of a four year's crop more than the value of fourteen bushels. This will bring the quantity of land required in Cumberland county necessary to supply a labouring man there, with food and drink for a year, to three acres: the fractions in this calculation compensating for those in the preceding.

A man must have not only food to support him, but cloaths to cover him, and a dwelling to defend him from the inclemency of the seasons.

The dress of a labouring man cannot be estimated annually at less than 25 dollars in this part of the country: he must have a hat, a couple of cravats, a couple of shirts, a couple of pair of stockings, two pair of shoes, a coat, jacket, and pantaloons and two pocket handkerchiefs per annum.

He must have a habitation which will cost him not less than five dollars a year.

Hence if 55 dollars require three acres, 30 dollars will require upwards of one acre and a half. To maintain a labouring man then, free in Cumberland county, will require not less than four acres and a half of cleared ground producing an average crop worth at leat fourteen dollars in the market.—It is true that every man, woman and child, will not consume as much food as a labouring man, but the expences of the more expensive ranks of society, will more than compensate for this. If a labouring man spends necessarily at the *lowest* rate 85 dollars a year, the average of the community, can hardly be estimated at less than 110 or 112 dollars, (about 25*l.* sterling) which will demand eight acres per head producing as above to support each man, woman and child in the county.

In other parts of the United States, the cheapness of land-produce, and of course the cheapness of living, compensate each other: so that although the calculation in dollars will be affected, the calculation in land will not: hence eight acres of cleared land at least, are necessary to the maintenance of every human being in the United States upon the average. The present proportion therefore of about eight millions will require about sixty-four millions of cleared acres. If the weight of grain, flesh, and home-

made spirits exported were known, the actual amount of cleared land in the United States might be approximated: though part of this export has been considered under the article cloathing.

I am not at this moment aware of any material fallacy in the above calculations: when I am further instructed, I shall be glad to correct my suppositions.

Would it be too much to calculate the average value in the market, of each acre of cultivated land in the United States, at ten dollars? I think not. It follows then, that the yearly produce of our agriculture is worth six hundred and forty millions of dollars!

How the bloated panygerics on foreign trade, dwindle into comparative insignificance, when set in competition with this! Can we avoid recollecting the old fable of the Frog and the Ox, so emblematic of the subject?

If the potatoe and the turnip culture, with that of carrots and beets for cattle on sandy grounds, were introduced into the regular rotation of crops in this country as in England, I have no hesitation in expressing my belief, that the produce of at least ten millions of acres might be saved. The introduction of these crops, would also of necessity lead to a strict system of manure management, and the introduction of sheep to be folded for manure, and of tap rooted plants so proper in a warm climate, where moisture is not found near the surface.

Of the quantity of Land necessary to maintain a Working Horse.

Such a horse well but not extravagantly kept, will consume 12 pound of hay and 8 quarts of oats per day. If his labour be constant, not less than two ton of hay, and a hundred bushel of oats per annum will suffice. His manure will amply pay for straw for bedding. Manure when once laid upon land, is well worth a dollar a load of three horses, in that situation.

Under the average cultivation of America, this produce cannot be raised on less than from 7 to 8 acres of land. Shoeing and stabling will cost half an acre more. So that the expence of a working horse, is somewhat more than that of a human creature. It is not only so on a large scale, but every traveller knows it is so, on a small scale also.

When I travel in the back parts of Pennsylvania for instance, I allow my horse, as follows. Hay at night 25 cents: 16 quarts of oats a day, 50 cents: present to the hostler in the morning for cleaning my horse 12 1-2 cents: similar present at one stopping

place during the day six and a fourth cents: shoeing and casualties six and a fourth cents. Total expence of a horse per day, travelling from 35 to 45 miles, one dollar.

Allowance to myself. Breakfast 25 cents: cold meal, or check at stopping 12 1-2 cents: supper 25 cents: liquor during the day 25 cents, being half a pint of spirituous drink: bed 12 1-2 cents: total 100 cents. Such at least were the prices from 1800 to 1812 in this state.

Again: at the present day 1814, the expence of a horse at livery at Carlisle is 120 dollars: to which shoeing is to be added. The expences of travelling have encreased about one third within these two years: partly owing to a state of hostility, and partly to the almost sudden introduction of the paper of so many banks. So that still a horse and a man travel as to *necessaries* at about the same rate per diem.

Calculations of this kind, may be considered as useful exercises in political arithmetic. I have often wished to see a set of questions published as exercises, in general and local statistics: and the same with a view to render chemical calculations also familiar to a student. T. C.

When I had composed the above, I met with the following remarks of a similar nature from the Quarterly Review, No. 19, which gives a somewhat different aspect of the same subject.

"Leaving the further discussion of this topic to wiser heads than our own, we will now conclude our article with a few remarks on the general subject of subsistence and population.

"It has been generally supposed that about one quarter* of wheat, convertible into about 480lbs. of bread, is sufficient for the annual sustenance of an individual, on an average of all ages. If this were true, it would evidently be easy to ascertain, in any country of which the extent and population were accurately known, the average annual consumption and reproduction of food, to estimate the degree of comfort enjoyed by the inhabitants of such country, &c. But the number and variety of articles really employed for the purpose of food are so great, as to throw considerable doubts on the truth of this approximation, and it is perhaps impossible to furnish any which shall be free from considerable error; and it may be of some advantage to know the attempts which have been made elsewhere to solve this intricate problem, and we shall therefore here state the supposed proportion of ani-

* Eight bushels.

mal and vegetable food consumed in the French metropolis about the time of the revolution, as tolerably applicable to Great Britain.

"The data for such a calculation were very numerous in France, where every province has been accurately surveyed, the population of every district regularly registered, and the consumption of the towns minutely ascertained, by means of the entrance duty collected at the gates. The calculators, amongst whom were Lavoisier and La Grange, were men of undoubted science, and the result of their labours is, that the annual food of each inhabitant, as deduced from the population at Paris, amounts to 642 French pounds, (693 English) of which the vegetable food, including corn, potatoes, fruit, and garden esculents of all sorts, forms 435lbs. (469 English,) and the animal food, comprehending meat, fish, butter, eggs, cheese, &c. 207lbs. (224 English.) Now, if it be considered that the extent of pasture land in Great Britain is, at least, ten times as great as that of wheat land; that this pasture is, from the moisture of our climate, remarkably fertile, and that our insular situation must supply us with a much larger portion of fish than our French neighbours can easily attain, it may reasonably be presumed that the estimate which allots a quarter of wheat to the subsistence of each person, probably exaggerates, by about one third, the real consumption of grain in this country, and reduces, in the same degree, the amount of our whole annual sustenance.

"This proportion will, of course, vary in different districts, in different classes, and in different seasons; but, in general, there is reason to hope and believe that the ratio of the more nutritious to the less valuable species of food, is still increasing in the general consumption; that wheat continues to supplant the inferior sorts of grain, and that the comforts of the poor are more widely diffused. Of wheat, indeed, it is impossible to state with accuracy the annual produce, but the inference may be indirectly proved by the augmented consumption of the food afforded to us by our colonial agriculture. On an average of ten years, ending in 1801, the mean annual consumption of sugar was between 177 and 178 millions of pounds, which, divided by the amount of the population, (10,942,646) gives 16lbs. as the consumption of each individual in Great Britain. By a similar calculation on the next ten years, we find the consumption augmented to between 19 and 20lbs. for each person, the annual average being 240,800,000lbs. and the population 12,352,144. This is exclusive of the distille-

ries, and of the export to Ireland; and as it appears from experiment, that a hundred weight of sugar is equal, in point of nutriment, to a quarter of barley, or $\frac{8}{11}$ of a quarter of wheat, it seems to follow that the coarser kinds of grain, formerly in general use for the manufacture of bread, are daily giving way to more palatable articles of nutriment.

"With regard to animal food, the abundance of which has been at all times the peculiar boast of the British islands,* we know, by the direct evidence of the markets in the metropolis, that the quantity consumed is regularly increasing. This, indeed, as we

* The above is an extract from the Quarterly Review for October 1813, page 173. I do not comprehend how the authors or editors of that work can reconcile this passage with the following taken from page 266 of the same Review, for the July preceding (July 1813.)

"Food of every description has risen to an extravagant and unprecedented price. *Butcher's meat*, once in ordinary use, is now nearly beyond the reach of the great mass of the people: the labouring poor can scarcely hope to taste it: and as to *fish*, whether in the metropolis or in the great inland towns, that may be considered as a prohibited article even to the middling ranks of life."

Nor can I see how the extract in the text is to be forced into coalition with the following passage from the Edingburgh Review for the very same month.

Ed. Rev. October 1813. Guarinos on Poor Laws. The Reviewers say, page 197, "The precious metals have been depreciated throughout Europe, in consequence of the productiveness of the American mines during the last forty years: and in our own country (Great Britain), the rise of prices which this necessarily produced, has been aggravated by a depreciation of our currency, occasioned by the issue of paper not convertible into specie. What have been the consequences? The price of labour has not risen in proportion to the price of commodities. But the labourer has the difference made up to him in the shape of poor's rate. An unmarried man can still support himself by his nominal wages. But a married man who has two children to maintain, receives *as a matter of course*, assistance from his parish. A calculation is made of the price of wages and of the price of bread. So much bread is allowed him according to the number of his family. What his wages will not furnish, the parish provides. This beneficent system, as it has been called, turns out to be an engine in the hands of masters, to keep wages as low as will suffice for the maintenance of the labourer and his wife, with a provision in the shape of charity, for the support of his children." The rest of the passage is well worth citing, but it is too long.

If these passages be correct, what becomes of the great and increasing abundance and consumption of animal food, the peculiar boast of the British islands? One fourth of the population of that country cannot afford animal food above once a week, perhaps not once a month.

have seen, has been considered by many writers as a proof that our tillage has not improved in a degree at all proportionate to our pasture lands; but in truth it is the peculiar advantage of the modern husbandry, that the quantity of winter and summer provender for cattle, yielded by the plough, greatly exceeds the annual produce of grass and hay from the same quantity of land. If, however, this were not notoriously true, there can be no doubt that our fisheries might, for centuries to come, effectually supply the deficiencies of our agriculture. There are, indeed, no bounds to the possible accumulation of animal food; and its efficiency as a resource, in the failure of other nutriment, is only limited by its very perishable nature; an inconvenience, however, very easily remedied, so that we may perhaps be justified in expressing our belief, that if the proposed imposition of a duty on foreign grain were accompanied by a repeal of the tax on salt, the growing population of these islands might be supported, for centuries to come, in the enjoyment of increasing abundance."

TO THE EDITOR OF THE EMPORIUM.

Pittsburgh, January 8, 1814.

DEAR SIR,

I ENCLOSE a letter to the secretary of the United States, in which there may be found some hints of value, respecting the best method of making turnpike roads. If you are of that opinion, it is at your service; and, although written expressly for the secretary, who is absent, and whose leave I cannot therefore obtain, I believe that there can be no impropriety in giving it publicity. I have added an appendix explaining, and enlarging upon, some points which it was not necessary to enter into more particularly in my report.

I am, very respectfully, yours,

B. H. LATROBE.

Washington, October 31, 1813.

The Honorable Albert Gallatin,
Secretary of the Treasury of the U. S.

SIR,

AGREEABLY to my promise, I submit to you such remarks as occur to me on the perusal of the contracts of Messrs. Cochran, M'Kinley, and Randal, for making the United States' road from Cumberland towards Brownsville.

These contracts require the following description of a road.

1. The road is to be levelled from side to side to the width of thirty feet.

2. In the centre of these thirty feet, a pavement (as it is now the mode to call it) of twenty feet is to be laid in two strata: the first to consist of stones, which will pass through a ring 7 inches in diameter; the second of stones that will pass through a 3 inch ring. The pavement is to be 20 feet wide.

3. This pavement is to be laid 6 or 9 inches higher in the centre than on the edges, and the earth is to be raised up to the edges to prevent the stones from separating, or, in the technical phrase, it is to be shouldered.

4. There is to be a ditch on the upper side of the road and *contiguous to the pavement*, that is, upon the shoulder, or, at most, but a short distance from it.

I make no remark on the stipulated slopes, as some alteration has been admitted respecting them.

I will now, in the order in which I have set them down, give you my opinion on each of these points of construction.

1. As the general course of the road, excepting where it crosses a valley, is carried along the side of the mountains, the general section will appear as in the plate.

To the width of the road there can be no objection (A),* nor

2. To the width of the pavement. But to the construction in every other point, I shall take the liberty of offering such objections as both theory and experience have suggested, and as in a great many instances have been found solid in my own professional practice.

The idea of covering a road with stones of different sizes has, I believe, arisen originally in the expectation, that the soft clay or earth, which in most instances constitutes the natural soil, would be less easily penetrated by large, (especially by flat stones) laid

* See Appendix.

immediately upon it, than by smaller stones, such as necessarily form the surface of paved roads, for the sake of procuring a tolerably regular plane upon which to travel. This idea has afterwards been strengthened by the *economy* of the practice; the quantity of labour in breaking the stone being thereby diminished. But the expectations both of utility and economy are perfectly fallacious. In the first place, nothing is so certain, as that the large stones, let them be ever so carefully laid out at the bottom, will, in time, come up to the top, and that the small stones will all go to the bottom: and this effect will take place, sooner or later, exactly in the proportion in which the road is much, or little, used; and also in the proportion in which the size of the large stones exceeds that of the small ones. At first sight this may appear extraordinary, but the effect is natural and unavoidable. It occurs thus: A heavy load presses upon the new road, and of course moves all the stones down to the lowest (B), the small stones at the top descend into the interstices, which are thus opened. Every new pressure and motion continues this process. If the lower stratum consists of stones which are large and flat, they will get to the top sooner than round stones. A very familiar example will elucidate this process. Every housekeeper, in breaking a loaf of sugar, shakes the broken pieces in a box. Those that are too large, soon come to the top and are broken smaller. In shaking chesnuts in a basket, the largest will soon be at the top, and exactly on the same principle. If it were not invidious, I would point out several turnpike roads, or parts of turnpike roads, in Maryland and Pennsylvania, which prove the truth of this fact. As to economy, (C) the calculation is in the next place quite as bad a one. Such a road soon wants repair, and no repair, excepting that of breaking up the large stones as fast as they appear, is an adequate one. These large stones necessarily range themselves on each side of the ruts, until they work themselves loose, and then they lie in the horse path. Such a turnpike is soon fit only for slow heavy waggons, and for those it is a very bad one.

Now in the United States' road, the lower stratum of stones will consist, at an average, of pieces weighing each more than 12 times as much as each of the pieces that constitute the upper stratum: or in other words, that have more than 12 times the volume, or bulk. Of course, many years will not elapse, before this road will be exceedingly out of repair and covered with loose stones of an average diameter of seven inches. In a level country this would be a less evil than among the mountains. Every obstruction

of seven inches is a very serious additional difficulty in an ascent of four and a half degrees, to a loaded waggon the greatest radius of whose wheels is probably only 2 feet 9 inches.

3. In all roads whatever, it is an error to raise the centre above the shoulders of the road. If there are instances in which it is useful, I have not yet seen them. In a road merely thrown up out of the common soil, where the ground is very level lengthwise of the road, it is perhaps as well to raise the centre, because it will soon be beaten flat in dry weather by being chiefly used, and in wet weather, when the ruts or tracks are deep it is of no consequence, because the water cannot run off rapidly: but in all other cases, the convexity of the road is assuredly injurious.

In respect to their level, *lengthwise*, there can be only two kinds of roads. The first, such as are perfectly level, of which the instances are in the United States chiefly confined to sandy situations; the second, such as are inclined more or less to the horizon, and which in turnpike roads are permitted by law seldom to exceed in acclivity, an angle of four and a half degrees.

In the first kind of roads, that is in level roads if in any, it might be supposed that a convex surface would be useful, because the water falling upon the road, might be thereby carried into the ditches on each side of it. And this would happen without injury, if the surface were perfectly hard, and no ruts or tracks were cut into it by carriage wheels. But as the construction of the road, and the law regulating the passing of meeting carriages occasions the sides of a convex road to be used, more than the centre, the outer wheels will always bear the principal part of the load and of course cut the deepest track. If the road be perfectly horizontal, lengthwise, the water which falls on the road will run across the road into the outer ruts on each side, which are the lowest and the deepest, and stand in them until it finds vent on to the shoulder in a place accidentally lower. The whole water of the road on each side for some distance, being discharged through a few of these openings, the road will be gullied across its edges—as daily observations may shew. But if the road were perfectly flat, there would not be cut so easily a leading rut on the edge, and the water would run off as fast as it rose above the surface in innumerable places, and much less rapidly. It would therefore gully much less, and nothing is so certain, as that, of roads entirely unimproved, the flattest parts are certainly not the worst, because

they have the fewest gullies across them, unless the ground is naturally boggy.

It would be out of place here to give instances for the construction of roads in countries which are not sandy and yet perfectly level. I will only remark, that to raise the whole artificial part of the road a foot above the common level, to lay it flat across, and to effect a very small alternate rise and fall at short distances longitudinally would be a mode perfectly efficient—*as very ample experience has proved.* (D)

In roads however that have a natural inclination to the horizon, it is difficult to conceive, how the idea of convexity ever obtained admittance into practice. The makers of roads appear to have been more anxious to get rid of rainwater than on any other account. It is not pleasant to drive or ride through ponds or puddles in the public highway: but there need not be any fear, that they will abound or exist, if the surface of the road be well and equally laid, even if the road were quite flat, provided it were raised above the level of the land on each side. But in a road which has a longitudinal declivity the only danger is, that the water will run off too fast, and carry with it all the small particles of hard stone, which filling up the interstices of the larger pieces, fix them firmly in their places, and which convexing them in some degree diminish the friction of the wheels and preserve the road. There cannot possibly be any occasion to turn off these particles from the road altogether by a lateral (producing with the longitudinal declivity an oblique) current of water, and of course an oblique gully, even if the road could possibly be quite smooth and free from tracks and ruts. But as no road, and least of all, a convex road can be free from ruts, while narrow wheeled waggons are used, the convexity of the road becomes *useless* at least. For the water will run from the centre into the first rut that it finds and continue to follow it until it finds some vent sideways, accidental or artificial. Since then the convexity of the road cannot perform the service expected from it, on account of the longitudinal tracks, the actual evils it creates ought surely to be avoided. The principal of these is the unequal bearing of the load of carriages upon their wheels, thereby wearing the lower side of the road, and forcing—by the cutting of leading ruts;—all the waggons to follow the same track, in which track there will be always *chuck* holes* in the lower side, whenever a large stone happens to be

* In the middle states, *chuck holes*, are sudden and deep depressions in the rut, and are always found opposite to the root of a tree, an old stump, or a stone.

firmly fixed on the upper. It would be certainly a more rational construction to build up the shoulders of the road firmly with large stones rather higher than the road itself, and then to fill in perfectly level across with equal small stones. A road so constructed would retain its materials much better and longer than the other, especially if care were taken, to prevent as much as possible a very rapid discharge of the rain water from it.

4. Contiguous to the pavement there is to be a ditch. This ditch must be certainly intended to catch the water coming down from the sides of the mountain, on the slope of which the road is made. To get into the ditch then, the water must pass over 4 or 5 feet of unpaved soil, the pavement being directed to be made in the centre of the 30 feet, which are to be levelled. I have understood, that the road continues in many parts upon one uninterrupted ascent of a mile and upwards. If this inclination should be of four and a half degrees and *regular*, it may easily be imagined, what will be the effect of a current of water running over the soft soil for a mile, and not only increasing as it descends in velocity, but also in volume. The bottom of the ditch would soon assume the parabolic line which the slope of all mountains acquire from the wash of rain water; and the pavement would gradually be undermined and tumble into it. But I presume that there will be as usual, stops thrown up to guide the current across the road at proper distances, which, although not provided for in the contracts, is so far a practical remedy for the evil. But it must, even if this be done, be apprehended, that in time a gully will be formed on the upper side of the road; and this gully will take place on the soil between the ditch and the hill, making the whole of the upper unpaved level one irregular ditch.

Having thus objected to the whole construction of the road, you have a right to expect, that I should point out, what, in my opinion, it ought to be. This I will not hesitate to do, with the most perfect candour and freedom.

1. The road being cleared 30 feet in width, the upper boundary of the road should be so laid, as that the earth to be cut from the slope of the hill will be sufficient to raise the lower or forced side higher than the other; the surface inclining towards the hill about 1 foot six inches. The made ground will settle so as to become perhaps nearly level, but it should always be rather higher than the opposite side to prevent the water from running across the road. The cut on the hill side should be, in general, per-

pendicular, if the nature of the soil is tolerably tenacious. A perpendicular bank will stand much better, than any slope over which the rain water produces a current.

2. A drain ought then to be cut above the road upon the hill-side, about 12 feet from the edge of the bank, and about a foot deep, and the earth thrown towards the road, in order to catch the wash of the hill, and to prevent its ever reaching the road. Great judgment is required in cutting these drains. Whenever an opportunity offers, the drain should be turned down the hill from the road, so as to throw off the water among the trees and a new drain be commenced. (See plate.)

In many cases, this is impracticable; but wherever there are ravines in the slope of the hill, it may be done to advantage. All the wash of the slope will, however, at last require to be discharged across the road into the valley. Which should always be done by a small drain or tunnel, instead of an oblique draft, or sink across the road—than which nothing can be a greater nuisance, or a more contemptible means of economy, if indeed any thing is saved by the contrivance. The use of resting ascending teams is pleaded, —*valeat quantum valere potest*.

This upper drain on the slope of the hill is of the utmost importance, and cannot, without injury, be omitted. It is an object of very small expense, and being confined to no particular spot or form, may easily be repaired or shifted, should the remainder break over it.

No very accurate rule can be laid down of the manner of conducting it, as the numerous varieties of situation which occur, must suggest as many, both in the length and direction of these drains.

3. The pavement of the road of 20 feet in width, should then be laid entirely on the hill side of its width, measuring from the perpendicular bank, so that there will remain ten feet of unpaved road on the other side. This will afford an excellent summer road; whereas, if the road be paved in the middle, and only five feet remain unpaved, no carriage whatever can travel upon it. (E).

If the pavement be thus laid close up to the bank, no gully can be made between the road and the hill—for the water that falls between the guard ditch upon the slope, and the road, is of very little importance, and being discharged over the hard pavement, can do the road no injury.

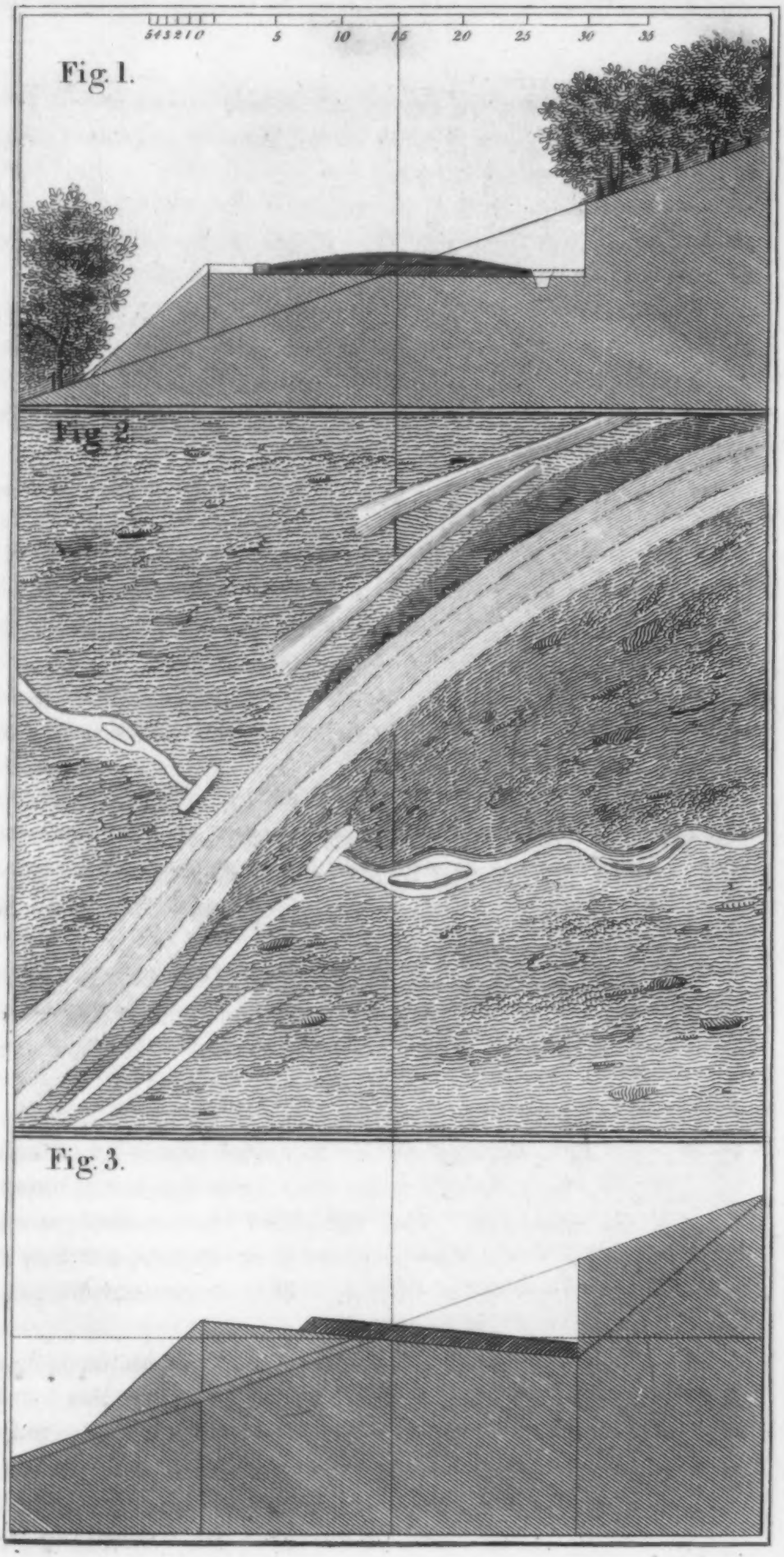

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Fig. 1.
Fig. 2.
Fig. 3.

There is no doubt, but that in the course of years, earth from the perpendicular slopes will fall on to the road; but nothing is then more easily removed, and by degrees the bank will gain a slope at which it will stand, and be covered with vegetation. If the soil be naturally good, this will happen in three or four years.

4. The pavement should be laid perfectly level *across* the road, or rather, if at all, inclining a little towards the hill. All the stones should be broken to the same size. Stones that will pass through a 3 inch ring are of a very good size. But it were better that they should be even larger, than that larger stones should be laid first, and smaller stones upon them. That they should be all equal, is much more essential, than that they should either be very small or the stratum be very thick. A road of equal stones laid 8 inches thick, will last longer without requiring repair, than a road of two strata of different sizes of a foot thick. And a little reflection will convince any one, that it must be so. A shoulder of large stones would indeed be very useful; for it is important to prevent the road from spreading; but a shoulder of earth is probably sufficient, and admits of an easier passage from the paved to the unpaved road.

5. Culverts, *or if it must be so*, stops (these stops are admirable contrivances to make a ditch of the summer road) across the road, must be made to take off the rain water which falls upon the road, and also the wash of the hills below the guard drains. These must be placed where the judgment of the superintendant of the road may direct, according to circumstances. But, as I said before, drains or culverts should generally be used, and always to discharge the water of the guard drains—and where flat stones abound, their expense is very trifling.

6. The principal part of the U. States' road being carried upon the slopes of mountains, the section of the road I propose would be thus. (See plate.)

But where it is to be carried on an embankment over a valley, over ground which does not rise on one side above, and on the other fall below it, or over a ridge, then the pavement should be in the centre of the road, and the whole road be 40 feet wide at least. But in the case of a perfect level across the road, there must be a ditch on both sides at the extreme of the 30 feet, for the purpose of preventing water from running on to the road, and to carry off the drainings of the road itself. The paved part of the road may be laid six or eight inches higher than the sides, if the road be level longitudinally: otherwise it is not necessary.

I have now performed my promise, although in a manner much less full and systematical than I could have wished. I have only to add a request, that you will excuse the marks of haste which you may observe, and receive this letter as a proof of my anxiety to be useful to the public.

I am, very respectfully, yours,

B. H. LATROBE,

Surveyor of the public buildings of the U. States.

APPENDIX TO THE PRECEDING PAPER.

THE above report, being written for a specific purpose, does not contain all that information on the method of making public roads, which is so evidently wanted. I will therefore offer to you a few further remarks, by way of appendix to the report.

A.

A road of twenty feet wide, in the paved part, and having on each side five feet cleared and levelled, is for all the purpose of travelling sufficient. But such a road does not admit of travelling excepting on the paved part; because the wheels of all our carriages run 5 feet 3 inches nearly, distant from each other, in the rut. A summer road is therefore out of the question; and indeed, unless the summer road be wide enough to admit two carriages to pass each other, the case of travelling upon it is dearly purchased by the necessity of turning off and on to it, even if it could possibly be an uniformly good road in good weather, and had all the advantages which your very judicious correspondent, O. E. in your 3d No. (October 1813) suggests.

The summer road is an object well worthy of attention in our country. If judiciously made, it will, in the middle states, and in common seasons, be a good road from May to the middle of July. The rains which fall in July and August would occasionally render it less eligible than the paved road; but from the end of August to the middle of November, often until Christmas, with the exception of a week or ten days about the equinox, it would again be the preferable road. During the month of January, the frost would generally give it solidity for a fortnight or three weeks; but from the first of February until some time in April, the breaking up of the frost, and the variable weather, would prevent its being much used. To make it useful, it is necessary, that it should not be the receptacle of the wash of the paved road, by being conti-

guous to and lower than the road—nor the depositary of the stones intended for repairs; that it should be protected by a ditch from the draining of the higher land; that it should be wide enough to admit the safe passage of two carriages, (not less than 15 feet); or that there should be a summer road on each side of the paved road of ten feet wide at the least, and that the law, which directs all carriages to turn to the right, should prevail in respect to these roads; or in other words, the carriages travelling upon them should be obliged to keep the paved road to their left hand. Of the necessity of each of these arrangements with respect to the summer road, every one who has travelled the Lancaster turnpike must be thoroughly convinced.

In mountainous districts, the maintenance of a good summer road will always be a matter of expense and difficulty; greater, probably, than would be rewarded by its advantages. And in the contracts for the great western road of the United States, therefore, it was right to omit any provision for such a road. But in the more level parts of our country, it is an object which would be well worthy of expense, and I think that by relieving the paved road from wear for 6 months nearly in the year, it would repay the money laid out in its maintenance. Its original construction is an object of small comparative expense.

B.

In passing along the Lancaster turnpike, I think in 1797, in a part then unfinished, I observed that a stratum of large flat stones was first laid upon the clay, and smaller stones broken over them. I stopped and stated my opinion to a person who appeared to superintend the work, on this injudicious mode of making the road; using all the arguments that occurred to me to convince him of the correctness of my remarks. He did not know me or my profession, and heard me with great civility; but I did not succeed in convincing him. In 1801, I passed over the same ground, and found the same person superintending a gang of men who were breaking up the large flat stones which then had arrived at the surface. There are many parts of the Lancaster road that now bear witness against this injurious practice; but the Reistertown road, near Baltimore, two or three years ago, afforded the strongest proof against the method of making roads by beginning with a stratum of large stones, that I have observed; for it was hardly passable for horses or light carriages, on account of innumerable loose stones lying and rolling in the horse path. The mode often adopted in covering turnpike roads is not very judicious, namely, to lay the stones down in

the road as they come from the quarry, and breaking them afterwards upon the road itself. It is no doubt the easiest method, and can be afforded at a less expense. But on the other hand it is open to great deception, and a very active overseer may be persuaded by appearances that the size of the stones is uniform, while the small ones cover large unbroken fragments. If the stones are broken up at the side of the road, and shovelled on from the heap, no such deception can take place.

C.

There is no word so little understood, or so much abused as the word *economy*. In nine cases out of ten in which it is attempted to be practised, its true meaning—the meaning proved correct by the result—is *the waste of ignorance or of inexperience*. The proverb, "Nothing is cheap that is useless," is like most other proverbs, fraught with an important lesson.

Nothing, in fact, is so cheap as the best workmanship employed on the best materials. Labour is productive in proportion as it is cheerfully performed; and no labour is cheerfully and well performed that is inadequately paid. Materials are cheap, in proportion as they are durable, and as the labour employed upon them is employed in sufficient quantity and with judgment. The bad condition and the unproductiveness of the stockholders of many of our turnpike roads, is to be attributed to the *hard* bargains, that is, the *cheap* bargains under which they were originally made, and the *cheap* materials of which they consist.

When however an important communication is for the first time to be opened, and when after every exertion that patriotism, and local, and personal interest combined, can make, a fund only adequate to make an indifferent road, can be raised—I then agree, that at all events the work should be *some how* performed, or, as our road-makers say, "*any how*." Such a road will always, before it becomes a good road, cost more in money, than a road well and permanently made at first, and undertaken, not by the lowest bidder, but by men who have honest principles and regard their engagements and their character, more than the amount of the profit they may make. Such men I have employed, and they are not difficult to be found. But it is hardly possible that a good road can cost too much, if the benefit to the community, and not to the stockholders is considered.

D.

The first turnpike roads made in the county of Essex, in England, over the perfectly level part of the county, and I believe all

the level turnpike roads, in level countries, which were constructed in the early period of this improvement of the public highways, were made on this principle, namely, of an alternate artificial ascent and descent.

My memory however furnishes me only with perfect knowledge of the fact; and I regret that I cannot point out the source of information from which I derived it. I recollect however passing over such a road in the hundreds of Essex, during some part of my residence of about ten years in England (about 20 years ago) and I also recollect having assigned, as reasons why the method was discontinued, that it was much more expensive than to *barrel* the roads (to give them a convex surface) and that the lowest parts were apt to be overflown. These are good reasons, although the discarded method is certainly preferable to that which succeeded it. The overflowing of the lower parts or kennels would be avoided by culverts or drains across the road. I know in our country no extensive levels, in which the soil is clay, and of course in which the roads are apt to be miry excepting the levels in the county of Fauquier, in Virginia, abounding in copper ore, and in which are the sources of the Occoquan. In Jersey, Delaware, and Maryland there are level and extensive clayey swamps, but all these may be drained, by carrying the drains to a sufficient distance. Having had occasion in the Peninsula between the Delaware and Chesapeake to run many miles of level through such flats, I have found them all to descend 6 inches in a mile to the S. E. In such situations, the whole road to the width of two rods (33°) should be raised above the level by the contents of deep and wide ditches on each side, before the hard material is carried on them.—And in my opinion they should be made perfectly flat, if not concave with occasional ditches and culverts or bridges across them. To make good roads over a rolling country, little art, but much labour, is required. The most difficult task, and that requiring the most art, is to make a good road over a level clay country.

In the level country between Retford and Gainsborough, in England, and throughout the clay flats of the counties of Nottingham and Lincoln, a sort of horse path exists, the continuation of which is ascribed to the Romans, and which is certainly not of very modern date. These paths are ditches, the bottoms of which are filled with sea-beach pebbles, (shingle.)

In several visits to that part of England I never saw them free from water; and have rode in them many miles, always wet above the horses fet-locks. They are to this day an excellent horse

path in the most miry country in the world.—I was informed that they had never, within the memory of man, been replenished with fresh pebbles. The proposition may seem strange, and will be no doubt ridiculed, but,—if travelling in water were not disagreeable,—I cannot help thinking that over a flat wet country such a ditch road 20 feet broad, filled with gravel or pebbles, or broken stones a foot deep in the bottom and having not more than six inches of water upon it, would be the best possible road that could be made. One cause of destruction would be avoided, the washing away of the hard particles separated by attrition; they would always remain and fill the interstices so as probably in time to convert the road into a sort of rock.—Nor would the frost, another powerful destroyer of roads affect it.—But it is useless to discuss a method which will never be used, and for which fortunately we have no frequent occasion.

Mr. Wilkes, an opulent banker in London, who possessed large estates in the county of Derby in England—and a spirit of enterprize combined with uncommon force of intellect, engaged largely in the making of turnpike roads in that county, and in conversations with him on that subject, I have received more information than from any other source whatever.

His roads were the best in England. On to some of them he had led a running stream of water; all that I saw were somewhat concave instead of convex. But least I should misstate any thing respecting them, for want of correct recollection, I will content myself with this notice of his operations, in order that you or some of your correspondents may be led to enquire whether or not something has been published by himself, on this subject. I have a faint idea that I have seen a description of the principles and method, by which he constructed his roads, in print.

E.

These oblique gutters are defended, as stopping places for carriages.—It is indeed, in common humanity, proper to stop in the gutter, after the horses have exhausted themselves by dragging a waggon or carriage over the ridge. But if the waggoner would carry along with him a block of wood with a handle, by way of a *scotch*, (catch) to his wheel he could stop where he pleased. The roller used in England would answer the same purpose, but although it effectually prevents the injury which might occur by the waggon's running back unexpectedly, it is not otherwise a better, nor a more convenient contrivance than the block.

Should the papers I now send, be honoured with a place in the Emporium, I will endeavour to collect all the information on pub-

lic roads, which my professional experience, or the books which I possess, or to which I can gain access may furnish and transmit it to you. Much is also to be said on the subject of wheel carriages, and the hint you have thrown out respecting the employment of small carriages in greater number, instead of heavy waggons, is well worthy of investigation.

B. H. LATROBE.

Pittsburg, Feb. 10, 1814.

I need hardly say, that I shall be greatly obliged by Mr. Latrobe's future communications on this important subject, so little understood upon principle, in the United States. My own collections on the subject of roads and one horse carts in particular, I will endeavour to introduce (if I can) in the next number: persuaded that though this be not a popular subject, it is a subject of great moment.

T. C.

ABSORPTION OF DELIQUESCENT SALTS.

Table of Efflorescent and Deliquescent Salts. By M. CADET. 26 *Till. Mag.* 242.

Efflorescent Salts. 288 grains.

Sulph. Soda	in 61 days	lost of water -	203 grains.
Phosph. Soda	39 - - -		91
Carbon. Soda	51 - - - -		86

Deliquescent Salts 288 grains absorbed

Nitrat Soda	137 days	- - -	257 grains.
Lime	147	- - - -	448
Magnesia	73	- - - -	207
Alumine	147	- - - -	300
Copper	128	- - - -	397
Zinc	124	- - - -	495
Antimony	124	- - - -	388
Manganese	89	- - - -	527
Muriat Lime	124	- - - -	684
Magnesia	139	- - - -	441
Alumine	149	- - - -	342
Copper	119	- - - -	148
Zinc	76	- - - -	294

Bismuth	114	-	-	-	174
Antimony	124	-	-	-	388
Manganese	105	-	-	-	629
Acetite Potash	146	-	-	-	700
Alumine	104	-	-	-	202
Acid sulph. alum.	121	-	-	-	202
Phosph. Lime	93	-	-	-	155

MANUFACTURES.

A Letter to a friend of the Editor, on Manufactures.

SIR—As I believe to promote the internal improvement, domestic trade, and industry of this country, is amongst the greatest services that can be rendered its society, you will not be surprised at my solicitude to engage your powers and influence in favor of a policy, in my opinion so perfectly adapted to preserve the government from the conflicts with, and influence of foreign nations; inseparable from a dependence on them for what is naturally, or has by habit become necessary to our citizens.

It has already been noticed, that Britain by the application to the affairs of society, of the powers of gravity, expansion, the various modifications of the mechanical principles, chemistry, all the arts and sciences, in short bringing to the service of her manufacturers, fire, air, earth and water, gives to each of them the power of producing sufficient to exchange for the labour of many agriculturalists, or persons employed in occupations that can only be performed by mere human labour. Let us endeavour to explain this imperfect subject and form some computation of what she gains in money, and then estimate from this, the number of human beings it would require to produce by their labour such an amount.

It is proper to premise, that the sums are stated on conjecture; but the principle is correct; and this paper is only intended to set YOU at work. The true data can be found in public documents, and British works on political economy, while much assistance may be had from Cooper, Fulton, T. Cox, Bolman, &c.

'In the last published number of the Emporium, I think Cooper states the saving to the British from using Watt and Bolton's

steam engine, at 75,000*l.* a day, or in round numbers, at twenty-five millions per annum: so, heading the account with this,

1st. Annual saving by Watt and Bolton's steam engine at - - - - - - 25,000,000*l.*

2d. Arkwright's spinning in all its varieties - 40,000,000*l.*

3d. Bridgewater's canal system including rail ways - - - - - - 7,000,000*l.*

4th. Threshing mill equal to 150 days labour at 2s. 6d. on 100 acres farmed after the stile of the Lothians near Edinburgh, and renting at 3 or 400*l.* per annum.

This last item I cannot fill up for want of documents to shew the extent of cultivated land in Britain, and the use of threshing machines thereon. But the saving from this, and the improvement of ploughs is very great; and enables the government of that country to tax all the land 15 per cent. per annum on its real rental. There may be other grand items that should be added to this account, and may possibly be suggested by the persons mentioned. To detail all the minor improvements that have been made, by employing the Tilt hammer, Roller, Screw, &c. in doing what other countries perform by the hammer, and manual labor, weaving by water, and having excellent roads, &c. &c. is not necessary here to state, and would require knowledge I do not possess; so these shall be thrown in, to keep the grand account entire.

Taking the total amount of saving by these four grand improvements at 75,000,000*l.* sterling per annum—and three shillings and four pence to be equal to one day's wages of a manufacturing workman, who for Sundays, holidays, and sickness, loses only 65 days in the year, (making 50*l.* sterling a year)—it equals the wages of 1,500,000 men.* This prodigious saving of human labour by manufactures and machinery, is the principal source which furnishes the means by which Britain supports her expensive government, her army, navy, clergy, nobility, revenue officers, subsidies, &c. which enables her to make roads, canals, &c. This gives her the command of 1,500,000 surplus men upon an equal population, whenever they are wanted for national purposes. Part of this she will lose by other countries adopting the same system, and working in the same manner for themselves or their neighbours: her statesmen are sensible of this, and do all they can to prevent it.

* The manuscript has it 750,000 men. T. C.

Now this addition of men whose work is performed by machinery, requires neither food, clothing, or lodging; the produce is clear gain, and adds more to the resources of a country like Britain where collecting taxes is so well understood, than the addition of German, Russian, or French territory, on which there existed thrice the number of agricultural inhabitants.

The success of manufactures depends on a decided national approbation and support; it is to manufactures we must look for the improvement of the country, by introducing good roads, canals, and rail ways. These in their turn will raise the value of land, and enrich and make comfortable the farmer; for generally, though our farmers are wealthy, they experience the plagues of poverty from not being able with ease to convert their abundance into the common medium of commerce, owing to the market being so far from them.

You must be very sensible such a system of home manufacture must have great influence in keeping America out of European squabbles: this is very important; and considering three fifths at least of the shipping merchants for the last nineteen years of my own experience, have either broken during their lives, or died insolvent, it furnishes room for reflection and inquiry a little farther into the mercantile system, before we assign to it all the good consequences which its friends are willing to suppose.

I would not from what has been said, have you conclude my opinions are hostile to commerce; on the contrary, I consider it essential to civil society: but its brilliant and striking character has a tendency to mislead our judgment and induce us to consider it almost exclusively as the source of productive wealth; which is not the fact; its foundation is on wealth already produced; but though it is an effect growing out of agriculture and labour, I acknowledge that in its turn it becomes a cause and assists the parents who give it birth. The brilliancy of foreign, is greater than domestic commerce, but in my opinion far less important.—Of this truth Britain is every day becoming more sensible; and her writers on political economy now acknowledge, that her domestic is at least six times her foreign commerce.

Would it be advisable for the president to recommend the consideration of this subject to Congress? Would it be of advantage to the nation to have a department under a minister or secretary of domestic affairs? The time is coming, when the nature and extent of our concerns will require a separation of the foreign and

domestic offices. It seems to me that order and expedition cannot be preserved without something of the kind, but perhaps we are not yet ripe for it. However, under these impressions I submit to your consideration the following remarks. Your's, &c.

J. R.

May 22, 1814.

ON MANUFACTURES.

SIR—I find it much more difficult to express on paper, in any thing like methodical order, ideas on manufactures, commerce, and political economy, than to talk about them; but it is pretty evident, and of course easily said, that the country that has its productive powers of *labour* and *capital*, duly apportioned into the three grand divisions of social employment, agriculture, manufactures, and commerce, will be the most independent of foreign nations; and its citizens will, in the most perfect manner, not rival, but support each other. On the contrary, a country all agricultural or commercial, while dependent on foreign nations for necessaries and comforts, has all its citizens rivals to each other. Farmers have little occasion to buy wheat and potatoes from each other; but the weaver, spinner, and smith, must purchase these articles; and their labour produces shovels, yarn, and cloth, with which they directly pay the farmer for his grain, beef, cotton, &c. or have the operation done through the merchant, as the common agent or factor.

As the United States, heretofore, have been occupied chiefly with agriculture and commerce, the country has been too dependent on foreign nations, and the people rivals to each other. The consequences of which have been very considerable. The interior is drained of its *increase*, to pay for foreign *necessaries;* the product of the farmer sells at a price reduced, in proportion to the expense of conveying it to the consumer; which on heavy or bulkly articles, such as flour and cotton, must be very great, when the producing places are at Boston, Pittsburgh, or Augusta, and the consuming places Paisley, Birmingham, or Madrid. The commercial class is too numerous; and their rivalship unduly raises the price of domestic articles at home, and lowers them abroad; the consequence of which is, that three fifths of the merchants on an average during the presidencies of Messrs. Washington, Adams, Jefferson, and Madison, have, either in the course of their

lives, or at death, been insolvent. The introduction of manufactures greatly alters this state of things, by affording employment for all kinds of genius, and any amount of capital; draws the superabundance of men and money employed in commerce, into manufactures; and bringing the consumer into the farmer's neighbourhood, can afford to pay him a higher price than he has heretofore received from the merchant; and at the same time, the consumer buys every thing at a price much below what it would have cost, had he resided in Manchester or Glasgow; in short, between them they save all the costs and charges incident to land and water transportation, agencies, commission, insurance, custom-house fees, and the whole list of direct and indirect foreign taxation; it is introducing into society the labour-saving principles, now well understood in manufactories. It would be unnecessary employment to enquire into the pro's and con's on the policy of manufacturing, urged twenty or thirty years ago. The astonishing improvement of arts and sciences has settled the question.

The propriety of manufacturing, might be questioned when the whole power of one individual was employed in making a single thread; when human beings carried on their backs, coals and minerals from the bottom of mines. A whole day was required by one man to make 10 or 12lbs. of nails. But every thing is changed. Now, all the powers of gravity and expansion, the elements of fire, air, water, &c. &c. are placed under the controul of man, and rendered equally subservient to his objects, whether delicately minute, or ponderous and bulky. A fibre of cotton or a bar of copper, are managed with equal facility, and the ends in view attained with the same accuracy. Capital employed in forming a dam, race, and saw mill, places a little ripple or a great stream, under the command of a few men, and makes it perform the labour of hundreds, at no expense of food, lodging or raiment. The same observation applies to the steam, and all other engines; so that manufactures are to nations, equivalent to encreasing their population. On reflecting upon these great improvements, the mind is struck with surprize, that no discoveries have been made to abridge the manual labour of husbandry. After the threshing-mill and cradle scythe, there is nothing of any consequence; nor from the nature of agricultural operation, is there a prospect of much alteration; and it is very probable that the United States, in exchanging her agricultural products with some of the European nations for their goods manufactured by the agency of machinery, give the labour of four farmers for one manufacturer.

Amongst the consequences resulting from this accession of manufacturing and mechanical power, is the ability accruing to these nations, of maintaining great armies and navies; too often employed to annoy the very persons who buy their wares.

It must be evident, that to bring into the service of man the mighty agents alluded to, and set them at work in preparing his food, cloathing, necessaries and luxuries, by habit become necessary; much capital, [accumulated labour, or in other words the product of labour not consumed,] must be invested in machinery and apparatus, which require time and labour to set up. Whereas all that a woman wants to enable her to spin one thread, is a wheel and reel, which can be procured for four dollars; and this is ten times the sum necessary to fit her up with a distaff; a business like this, may be begun and laid aside, on the exigencies of a week. Not so the other. Before a thread can be made, many thousand dollars must be expended on the mill and apparatus. A nation, to avail herself of the benefits growing out of the great improvements that have been introduced into the arts and sciences, must cherish the infant efforts of her citizens by *judicious* and *stable* laws, and inspire them with confidence to embark their property and time in those undertakings. A manufacturer and his capital have a fixed character, they cannot be changed like the merchant. Under these circumstances, no nation will progress, except her legislature contributes protection; and the farther other countries have advanced before she begins, so much stronger is the protection required. The United States possessing vast resources in the vigour and activity of her people, extent and quality of soil, uniformity of government and language, mines, forests, &c. &c., I once thought that a fixed duty of 35 per cent., would be sufficient to cherish those manufactures essential to her independence and wealth, but on more maturely weighing the subject, I think the import should be raised to fifty; that in two years from the termination of the present war, 5 per cent. should be taken off the import, and at the end of three years another 5 per cent., and at the end of four years a farther reduction of 5 per cent. and the remaining 35 per cent. to be considered perpetual. This gradual way of lowering the duties, would be favourable to the revenue, the manufacturers and holders of foreign goods. A rapid reduction will be most mischievous to both the latter, and this cautious way of proceeding, would afford time to apply any special remedies that particular cases might require. It will soon be found that many particulars can maintain their ground advantageously, at much lower protecting

duties than 35 per cent.; indeed, there is no doubt that after a home manufacture is under way, and has for some time got possession of the market, it can combat the foreign one with greater effect at a duty of 10, 5 or no per cent. than it did in infancy at fifty.*

Compared with the duties of importation imposed by foreign nations, 50 per cent. is low. I think the duty on a yard of woollen goods imported into Britain is $ 6 22 cents, be its quality what it may; even the raw materials of cotton, turpentine, logs of wood, &c. exceed in France and Britain, what is here charged on their gewgaws.

The mischievous effects on the settled regular business of a country, from excessive importations, arising out of particular causes, such as a country being instantly shut out from some market heretofore enjoyed by her; sending the excess here, gluts the market, and stagnates in the hands of the manufacturer, many months produce: this is a serious evil, and Britain either has guarded herself against this, or soon seizes the event, and by new duties, turns it to the account of her revenue; some such provision should be made in the United States; I am strongly impressed with the opinion, that from this will come the ruin of many of our manufacturers, and even some of the manufactures themselves; but 50 per cent. would extend to them, a fair chance of success, and nothing farther should be tried at present.

In such a population as Philadelphia, there are now numbers not employed, who in the existence of manufactures would gain considerably; and the aggregate of their annual wages, would be an immense sum added to the nation's wealth.

Indeed, it has been stated by some political writer to Napoleon, that it was in the villages of France, that he could conquer the British navy. Bonaparte was a better judge of military affairs, than of political economy, and rejected the plan. Industry is not so brilliant as military exploits, but its effects are frequently more successful, always safer, and it increases the resources to support the latter. If congress does not very soon act decidedly in favour of manufactures, the spirit will generally languish, and probably some of the establishments perish: which would be a circumstance much to be regretted, as in this part of the controversy with the enemy, we have been surprisingly successful.

I am respectfully,

J. R.

* It would appear to me protection quite sufficient, if beginning with 50 per cent. 5 per cent. were taken off every two years, till the permanent duty should be reduced to 15 per cent. T. C.

CHROMAT OF LEAD.

Mr. William Hembel, jun. of Philadelphia, having had much experience in making the chromat of Lead, I wrote to him for his process; which, with the liberality so common among scientific Chymists, he has been good enough to send to me. I have seen no specimens of the colour equal to what he has made. T. C.

DEAR SIR,

THE great difficulty in preparing the Chromat of Lead, is to preserve an uniform colour during the whole precipitation with nitrate of Lead. Vauquelin, Murray and other writers, found the difficulty so insurmountable, that, they concluded, Chromat of Lead could never be made subservient to the arts.

In my first experiments, I experienced similar disappointments; prepossessed with the opinion of Mr. Vauquelin, I concluded, that, the different colours of the same precipitation, were occasioned by different quantities of alumina, or magnesia, which the chromic acid carried down, by an affinity too strong to be interrupted, otherwise than by the regular order of analysis.

It will however be obvious to you, that such a proceeding would be totally incompatible with the despatch of the manufactory, even supposing that the manufacturer possessed the talents to conduct such complicated processes, which it is often necessary to modify, from causes which can only be appreciated by the practical chymist.

Disappointed in every attempt to procure a deep and uniform colour, I finally separated all the earths, previous to adding the nitrate of lead; under the persuasion, that when they were removed no obstacle would remain to prevent an artificial product being obtained equal in beauty to the natural: but the result disappointed my expectations, and at the same time instructed me, that it was not the earths only, but *carbonic acid* also, which had hitherto baffled my endeavours.

I had long satisfied myself, that no quantity of acid was sufficient to expel all the carbonic acid from alkalies, in the time allotted to processes of the laboratory, unless the solution was heated to the boiling temperature at the same time; and reasoning from that fact, I concluded, that the *carbonic acid*, which the alkali of the nitre acquired during the fusion of the mineral, combined with part of the nitrate of lead, which precipitating with the chromat

of lead, occasioned all the varieties in shades, in which the pigment was exhibited in our experiments. Under that impression, I digested a portion of the precipitate which I had obtained in former experiments, in cold diluted nitric acid, a slight effervescence ensued; and the colour immediately improved to a lively orange yellow: nearly equal to that which you think superior to any you have seen prepared.

The result of the above experiment suggested the following processes. The first I have verbally communicated to several persons, who have undertaken to prepare the pigment for sale: but, from the inferior colour which they produce, I fear that more knowledge of chymical processes is necessary to enable a person to conduct the second than is common to mere manufacturers.

1st. Reduce any quantity of chromat of iron to a powder sufficiently fine to pass through a sieve of the finest bolting cloth; triturate half its weight of nitrat of potash, and mix the two powders intimately together. Introduce the whole into an iron pot (I use the pot of a cast iron glue-kettle, having a cover) and add as much water as will reduce the whole to the consistence of thick paste. Place the pot on some lively coals, and cause the water to boil, stirring the whole occasionally with a stick, until the mass is dry; then introduce the pot into an air furnace, and heat it about a cherry red; but be careful not to increase the temperature as long as oxygen gas is evolved, otherwise the pot will be melted. The escape of oxygen gas will be made manifest by holding a live coal at the juncture of the pot and cover; as long as oxygen escapes, the coal will burn with increased splendor; when the splendid combustion ceases, the fire should be augmented until the pot is of a very bright red, and kept at that temperature about one hour. The pot should now be suffered to cool in the furnace, to prevent its cracking by a sudden change of temperature; and when cold, it is to be well wiped on the outside, and placed in a tinned kettle containing a large quantity of water, which is to be boiled until the mass can be detached from the pot; when the latter may be withdrawn. The boiling must now be continued for half an hour, occasionally bruising the hard mass at the bottom of the kettle, after which it may be withdrawn from the fire and suffered to settle for a few minutes. When the supernatant liquid is clear, it is to be decanted into a convenient vessel, and the kettle filled with fresh water, which must be boiled on the residuum, and the process repeated as often as the liquid appears to be strongly coloured. After a few boilings, the liquid (if the quantity of water is large) will

be so faintly coloured, that a further continuance of the boiling will be a waste of time; then the remainder, which consists of oxyded iron, may be thrown away, and the kettle rinsed clean. A part of the liquid is now to be introduced into the kettle, and briskly boiled, supplying the waste as it boils away, until the whole is introduced therein; it should then be concentrated until it is nearly at the point of crystallizing when cold; when it may be thrown on a filter, to separate the iron which may remain suspended therein, together with the magnesia which will have precipitated.

On gradually adding nitric acid to the filtered liquid, a precipitate will appear, which is the earths held in solution by the potash of decomposed nitre, and disengaged by the acid combining with the alkali; but attention must be paid not to add the acid in excess, otherwise the precipitate will be immediately re-dissolved; the better way will be to add less acid than is deemed necessary, to separate by filtration the precipitate which may appear, and to the filtered liquid add fresh acid, then filter again and repeat the process as often as a precipitate falls; by that cautious proceeding the separation of the earths may be considerably approximated, but not entirely effected.

Nitric acid is now to be added until the solution tastes sensibly sour; it is then to be boiled in a glass vessel, and whilst boiling a few drops of acid are to be added as long as an effervescence or even globules of air appear to rise from below the surface of the liquid, on each addition of nitric acid; when they cease, the solution must be briskly boiled for fifteen or twenty minutes, which will completely expel the *carbonic acid* which may remain.

Into the above solution, either hot or cold, a solution of nitrate or acetate of lead is to be poured so long as a precipitate appears: *or the acetate, if clean, may be added in powder or lumps*, which I think preferable, as we thereby avoid the bulky solution which is so very inconvenient where capacious glass vessels are difficult to procure. When the precipitation is completed, it should be thrown on a filter and well washed, by filling the filter fifteen or twenty times with boiling distilled water; the water being suffered to run entirely off, before the filter is again filled. As the beauty of the colour and the property of drying quickly will greatly depend on its being well washed. It may be interesting to add, that I have found strong boiling of river water a good substitute for distilled; the water was boiled for half an hour in an open vessel, then suffered to cool, it deposited a considerable sediment of vegetable matter, and in winter, some carbonate of lime, which

was separated by filtering; the water was again boiled in a clean vessel, and used hot, as above directed.

After the lotions are concluded, the filter may remain in the funnel for 24 hours to drain; the funnel being covered with paper, to prevent the pigment being injured by dust, &c.; the paper will then bear being raised without danger of tearing, and may be laid on a chalk stone to dry, with a sheet of bibulous paper laid on its surface.

My second process, which furnishes the finest specimens, is as follows:—The mineral is treated as in the former process, except that instead of adding *nitric acid* to separate the *earths from the concentrated solution;* I add a saturated solution of *muriat of ammonia*, an abundant precipitate immediately appears, the muriat of ammonia is added until it ceases; the whole is then thrown on a filter: by this means I free the solution of *all the earths*. Into the filtered liquid I add nitric acid until it is sensibly sour, and boil *immediately;* whilst boiling, a few additional drops of acid are added, to ascertain whether the liquid contains any *carbonic acid*, if an effervescence ensues, or small globules of air are perceived to rise from below the surface, more acid is added until they cease, when clean acetate of lead in powder is *immediately* added, as long as chromat of lead is precipitated. The chromat is then separated by filtration, and the washing, &c. conducted as in the former process.

This last process (if properly conducted) always produces deep orange colours of great beauty. Of six specimens which I prepared, no difference could be observed in the shades, by the most discriminating eye; but it is indispensable to success, that there be no delay, after the *carbonic acid* is expelled by adding nitric acid and boiling: as the muriatic acid of the muriat of ammonia, decomposes part of the chromic acid, oxymuriatic acid gas is abundantly evolved, and the solution changes rapidly to a dark yellowish green, the decomposition however is only partial; yet the least delay in adding the acetate of lead would render it general, and thus defeat the previous labour.

With respect to the permanence of the colour, I cannot say much from my own experience; the opinion of artists I find different on the subject. I will however observe, that no inference should be formed from the specimens which have been offered to the public; they are all contaminated with *carbonate of lead*, a pigment which is well known to blacken, the instant it comes in contact with sulphuretted hydrogen gas, or the effluvia from pu-

trid animal or vegetable matters; to that change I attribute the deterioration which was experienced with the chromat of lead hitherto used. I will further observe, that I think oil made drying by oxyded lead, should not be used, owing to the great affinity which the oxyds of lead have for carbonic acid, particularly when in contact with substances capable of affording that acid by decomposition. I will not say that I know the oil is *partly* decomposed, but I *think* I have observed the phenomenon: a board was painted with the pigment and poppy oil, it appears to stand very well.

In the above, sir, I have endeavoured to lay before you the reasoning which led to the processes I now pursue; should you publish them, no person will be disappointed who follows them faithfully.

Your friend,

WILLIAM HEMBEL, jun.

THOMAS COOPER, Esq.
Professor of Chymistry,
Carlisle College.
June 28th, 1814.

COOKERY: A SALMAGUNDI.

Νυν δε μνησωμεθα δορπου
Καί γαρ τ'ηυκομος Νιοβη εμνησατο σίτου
Τηπερ δωδεκα παῖδες ενι μεγαροισιν ολοντο.

Now let us think about supper: for the fair haired Niobi did not forget her meals, although she had twelve children lying dead in her house.

SO spake the swift-footed Achilles to king Priam, who came to beg the body of his son Hector. Harry Fielding, too, has a dissertation in Tom Jones, to prove that even violent love will not take away the necessity of eating, or entirely destroy the appetite for a good dinner. This, in my opinion, is also proved by the common practice in every country, of drinking to your mistress's health, which presupposes good eating to be washed down with the good wine used on such an occasion. The same inference may be fair-

ly, though indirectly, deduced from the old proverb, "Excessive sorrow is exceeding dry." Hence I may conclude it as a common practice, that whether a man be in grief or in love, he will eat a good dinner if it be set before him, and the stomach calls for it. Montgomery, the poet, thinks with me in his verses while in prison.

"When drest I to the yard repair
And breakfast on the pure fresh air:
But though this choice Castalian cheer,
Keeps both the head and stomach clear,
For reasons strong enough with me
I mend the meal with toast and tea.
Now air and fame, as poets sing,
Are both the very self-same thing,
Yet bards are not cameleons quite,
And heavenly food is very light;
Who ever din'd or supped on fame
And went to bed upon a name?"

So in the old song, Bacchus very shrewdly asks Appollo,

"Who ever got fat at the sound of a string?"

Now, every common practice, that is, a practice universally followed in all ages and nations, may be considered as a law of nature and of nations. Thus, Grotius, L. 1. cap. 1. sect. 12. parag. 1. sub fin. *Juris naturalis esse colligitur, id, quod apud omnes gentes, aut moratiores omnes, tale esse creditur. Nam universalis effectus universalem requirit causam; talis autem existimationis, causa vix ulla videtur esse posse, præter sensum ipsum communis qui dicitur.** In support whereof, according to the laudable practice of his day, (now almost suppressed through the ignorance, idleness, or plagiaristical concealment of modern authors) he gives us eleven quotations: to wit, one from Hesiod, a case directly in point, as the lawyers say; running upon all fours; *proprium quarto modo*, as the logicians have it; together with a dictum of Heraclitus; three passages from Aristotle; one from Cicero; one from Seneca; one from Quintilian; one from Porphyry; one from Andronicus Rhodius; and one from Plutarch. To make up the baker's dozen, he adds in a note, another from Aristotle; another from Seneca; and another from Quintilian; and throws

* This is the foundation of the wonderful discoveries in Dr. Beattie's Essay on Truth.

into the bargain, still one more from the last author; and a spick and span new citation from Tertullian. His annotator, Barbeyrac, out of sheer envy, spite, and vexation, because these annotations of the author, rendered unnecessary those of his commentator, most seditiously, and in contempt of his superiors, declares, *omnia ista loca, si duo priora excipias, parum ad rem referunt.* In the same prudent spirit of leaning upon sage authorities (upon a broken reed as Horn Tooke, of seditious memory, would call it) my lord Monboddo, having asserted, that "when a man opines, he must opine some thing; and therefore the subject of an opinion is not nothing," does not venture to turn out into the world so profound an observation, unprotected; he therefore fortifies it by the authority of Aristotle. So in later times, the very learned Dr. Magee, now professor of mathematics in the college at Dublin, proves the doctrine of atonement and vicarious suffering, the absolute inefficacy of repentance, and that without the shedding of blood there can be no remission, by the general prevalence of human sacrifices throughout the ancient and modern world. This is a doctrine, which if an unlearned christian finds clearly laid down in his bible, he adopts at once, and looks no further. Not so the learned doctor. He brings his case into court with a full determination to make security doubly sure. He therefore cites, as witnesses in his behalf, authors of all ages and nations, ancient and modern, of all ranks and descriptions, original and at second hand, in most erudite and overwhelming confusion. To be sure, had he arranged and marshalled them either in order of date, or reputation, or language, or subject matter—had he distinguished between original and hearsay testimony, or between the rules of credit or credibility, he might perhaps have escaped some legal objections to testimony, but he would have lost ground perhaps in the effect and grandeur of display.

First he offers to the court, Herodotus, and Porphyry, and St. Augustin, and M. de Pauuw: then Sanconiathon, as quoted by Philo, as quoted by Eusebius. Then Keisler the modern, and Diodorus the ancient, and Manetho the Egyptian as cited by Plutarch. (He forgot Berosus, who generally composes one of the firm of Sanconiathon Manetho and Co.) These are backed by Murtadi the Arabian, who is supported by Mr. Maurice the Englishman, and M. Savary the Frenchman. Then we have an account of the oblations of the Chinese monarch Ching-tang from Martin's historia Sinensis: and those of the Persians from Herodotus, and Xenophon, and Arrian, and Strabo, and Suidas, whose evidence (to clear it from all objection) is tri-

umphantly supported by Monsieur Barnaby Brisson! Then, lest the Rev. Mr. Maurice should be deemed insufficient, he is corroborated by Orme, and Sir W. Jones, and Mr. Wilkins, while Holwell and Dow who have hitherto passed through the world with good name, fame, credit, character, and reputation, are on this occasion unmercifully lashed by the learned Doctor. The jury are then enlightened upon the devotional practices of the Druids, as detailed to us, by Diodorus Siculus, and Lucan, by Cæsar, and Tacitus. These religious acts of the Druids who sacrificed their *enemies taken in war*, were nothing however to the pious orgies of the Greeks, who cut the throats of *their friends before battle*, as we are told by Phylarchus, and Pausanias, and Fulgentius, and Apollodorus, and Plutarch, to say nothing of Suidas, who whispers a few greek words in assent. Upon a similar subject, Plutarch, Livy, and Pliny, are kept in countenance by the authors of the Universal History, and by Porphyry. Evidences now crowd thick upon us; some are introduced for the first time, others for a second examination: Herodotus, Strabo, Jornandes, Cicero, Cæsar, Procopius, Tacitus, Pliny, Sanconiathon, Plato, Silius Italicus, Justin, Ennius and Diodorus, succeed each other *velut unda supervenit undam*. All these testimonies, a man well red in indexes, might perhaps have mustered with great labour, as Dr. Magee has done: but the Doctor is no common writer, or every day reasoner: he aims to "snatch a grace beyond the rules of art," and to fortify the scripture doctrine of atonement, he boldly appeals to the practice of the Canaanites! (Lev. xx. 23.) The Hivites, Hittites, Amorites, Jebusites, Perizites, and so forth, are passed over. Then we have the corresponding customs of the Arabians again; of the Cretans, Cyprians, Rhodians, and Phocæans; with those of Chios, Lesbos, Tenedos, and Pella, from Porphyry as quoted by Eusebius, and from Monimus as retailed to us by Clemens Alexandrinus. So that the universality of the principle and practice of atonement and vicarious suffering, in the heathen world, "cannot reasonably be questioned." Lest however it *should* be questioned by some unbelieving wight, the learned Doctor goes on more fully to strengthen his positions, by Euripides, Tacitus, Plutarch, Pliny, and Plato, attended by Professor Meiners and Dr. Cudworth, who vouch to warranty all the ancients, wherever their testimony can be pressed into the service.

Then the Doctor proceeds to shew that the same principle and practice has obtained among all the most polite and civilized bar-

barians and savages of modern days. Mr. Thorkelyn the advocate of the slave trade, leads up the train of witnesses: he is succeeded by Ditmarus who is called in by Loccenius. Then come Adam Bremensis, and St. Boniface, Mallet, (a sad rogue) Jortin, and Fleury, as to the practice among the northern tribes of Europe. Then he glances over the various nations of Africa, and the islanders of the South seas, of Ota-hai-te and Tongataboo, concerning whom we are presented with the testimony of Snellgrave and captain Cook. As to the American savages at the first discovery of this continent, Acosta, Gomara, Antonio de Solis, Clavigero, give ample testimony. The East Indian rites and ceremonies of similar description are attested, by Maurice, Mickle, and Crauford: by Dow, Holwell, Grose, and Buchanan: not to mention that indefatigable and unequalled citer of authorities, Professsor Meiner's,* who, though he had long ago forestalled the Doctor, is kept too much in the back ground.

* Dr. Magee is original only in his mode of argument: not so in his body of quotations, as the following extract may shew, from Meiners' Syllabus of a History of all Religions.

SECT. VII. Nor was it less universal a matter to offer peace offerings upon misfortunes, or to endeavour to avert the consequences of misconduct. Expiatory sacrifices, and trespass offerings are therefore to be met with amongst all the nations of the new and old world.* Nay, they have supported themselves amongst such nations as have long since banished every kind of bloody rite.†

* By the Ægyptians, Herod. Plutarch. l. c. et Schmidt, *p* 312. By the Israelites, 278, 79. Outram, *p* 118. Mich. Mosaic Laws, *v* 98. 3. Mos. 5. *v*. 2, 3. also c. 4. and 16. By the Greeks, Plat. de Republ. ii. *p*. 102. edit. Massey. The Romans, Liv. c. 31. c. 12. L. 34. c. 55. L. 28. c. 11. L. 29. 14. Plutarch. in Coriol. ii. *p*. 129. By the Negroes, Loyer, *p* 248. De Bry, vi. 20. And the Siberian Heathens, Georg. *p* 389. By the savage Americans, *p* 348. Charlev. Jour. By the Amboinese, Valent. iii. 10. By the Hindoos, Roger, i. 5. ii. c. 15.

† By the Heathen Greeks, and Mahometans, Shaw, *p* 333. Guys, i. 466.

SECT. VIII. The causes which led men to offer other things, inclined them likewise to offer up men; they therefore either offered up themselves willingly, or their brethren against their wills. The former was commonly done, for three reasons; either to follow certain persons into another state,* or to appease their angry gods, or to enjoy the felicity of another state earlier, and in a greater degree.

* This was done by all the Scythian and Celtic nations, Cæs. vi. 21. Tav. c. 27. German. Herod. V. Pellout. 10. 113. 119. Conner. i. 81. 83. Tavern. ii. 162. Historic. Fragm. *p* 126. By the Hindoos. In the Indian ocean, Recueil des Voy. des Hollandois.

So that there can be no doubt upon earth, but the principle of vicarious suffering, and the practice of human sacrifice, is, according to the rule laid down by Grotius, and fully adopted in principle by Dr. Magee, part and parcel of the law of nature and nations.

SECT. IX. Compulsive human offerings were made either for the sake of obtaining health, a victory or some other blessing; or to thank them for favours already granted; or to learn future events from them; or to appease departed souls, by sending their friends and servants after them; or finally to appease the anger of the gods. (See the notes.)

* Scandinavians, Herod. iv. c. 94. Barthol. *p* 230. 700. The Greeks, Lucian, i. *p* 466. The Negroes, introduc. Projart. *p* 269-86-99. The Inhabitants of Paos, and Pegu, Sonnerat, ii. 39. Rhodes, *p* 349. The American Savages, i. 120. Coreal. The Peruvians, Acosta, *p* 229. The Tunquinese, Ovingt. ii. *p* 52.

† Upon this principle it was that they brought human offerings to Queen Amestris, vii. 114. Herod. The Goths, Jornand. ap. Grot. *p* 617. And Procop. ii. c. 25. Keisler, *p* 134. The Galatians, *v. p* 355. Diod. Wessel. The Peruvians, Acosta, *p* 227. The above mentioned savage nations in Africa, ll. cc. and Snellgrave, *p* 36. 54. The Romans, Dio. Cass. l. 43. c. 24.

‡ Strabo mentions this of various nations, iv. 303. vii. 451. xi. 768. This also happened on the island of Mona, xiv. 30. Tacit. among the old Northern nations, Mallet, *p* 84. In Peru, i. *p* 52. Zarate. And in the Mysteries of Mythras. iii. c. 2. Socr. Hist. Eccles.

§ This also took place amongst the old Celtic and Northern nations, Her. iv. 71. Mallet, *p* 213-214. Barthol. *p* 506, 507. Also amongst the Greeks and the Romans, Homeri Ilias, XXIII. *v* 179. Just. xi. 2. Virg. Æneis, x. 517. 533. xii. 948. Varro ap. Serv. ad. iii. 67. Farmer, *p* 441. Also among the Mahrattas, *p* 126. Histor. Fragm. Also amongst the Negroes, i. 315. Oldendorp. Cavazzi, i. 250. 381. 391. 401. ii. 122. 168. Des Marchais, i. 315. ii. 74. Projart, *p* 299. 329. Also under the Moguls and Chinese, Gentil. ii. 151. Voy. au Nord, vii. *p* 58. Also amongst the North American savages, Charlev. *p* 247. The Taencas, Voy. au Nord, *v* 129. Also amongst the Peruvians, and Inhabitants of Mexico, Acosta, *p* 209. 211. 227.

‖ This was the custom amongst the old Celtes and Sclavonians, Anton. *p* 64. Tacit. de Mor. Germ. c. 9 et 39. Barthol. *p* 228. 323, 393, 394. Mallet, *p* 83. 86. The Taurians, Her. iv. c. 103. The Galatians, Just. L. 26. c. 2. Diod. *v. p* 355. Ed. Wessel. The Gauls, Cæsar, vi. 16. Massagetæ, i. 216. Herod. The Greeks and the Romans, Dionys. Halic. Antiq. R. i. 38. Plut. ii. 366 et seq. iii. 625. vii. 102. 143-45. Lact. Inst. Div. i. 21. Plin. L. 28. c. 2. Suet. in Calig. c. 27. in Ner. c. 36. Porph. de Abst. ii. c. 54-56. Pausan. iv. 9. vii. 19. 21. viii. 2. Meursii Lect. Attic. iv. 22. Miscel. Lacon. ii. 14. Farmer, *p* 441. The Phœnicians and Carthaginians, Justin. xix. 1. xx. 14. Plut. vi. 633-35. The Ægyptians, Schmidt, *p* 277. The Tunquinese, Rhodes, *p* 119. The Inhabitants of Borneo, Forrest, *p* 368. The Negroes, Loyer,

I confess I was not only much instructed and greatly edified, but also, in no small degree, solaced and comforted by this elaborate dissertation of Dr. Magee; in as much, as it tends strongly to prove, that the kings and conquerors ordained under the dispensations of providence, to superintend the government of the various nations of the earth, are by no means deserving of the ignorant obloquy which it is too common to throw upon them; and that even the human sacrifices of Bonaparte himself, may possibly proceed from his deep sense of religion, and his profound respect for the laws of nature and of nations.

It is surely among the desiderata of human knowledge, that Dr. Magee should apply his new method of theological demonstration, to mathematical instruction, so much more luminous and convincing as it seems to be. If he does not secure his invention in the patent office of his own country, I greatly fear that some ingenious Yankee speculator in patent rights will forestal him, and claim it as a notion, the genuine offspring of some cisatlantic brain. I cannot say how far Dr. Magee coincides with the limitation of Grotius, *saltem apud moratiores omnes;* but be that as it may, I do suppose the learned Professor, in his adopted character as prochein amy of Mrs. Bull, will be as fairly entitled to remuneration as Dr. Horsley; and if Hurlo Thrumbo were alive, he would certainly obtain it. In our state, the *circular mileage* of these witnesses, so liberally allowed by the Legislature of Pennsylvania even to the President Judges, would form a very pretty item in the bill of costs,* made out in the Doctor's favour, and amply re-

248-49. Oldend, i. *p* 329. The Floridans, Peruvians, and Mexicans, Acosta, 227. 234. Gage, i. *p* 154. The Otaheitians, Forster's Observations, *p* 476. Cook, i. 185. The Inhabitants of Madagascar, ii. 52. Sonnerat. The Bramins and Hindoos, i. 186. Sonner. The Inhabitants of Formosa, Psalman.* *p* 43. 60. The Chinese, Memoir. concer. les Chinois, ii. 400. In order likewise to appease the Gods, they murdered or exposed sick persons. This was done by the ancient Persians. See my Dissertation on the Religion of the Persians. This is likewise still done by the Mingrelians, Lamberti, *p* 153. The Hindoos, Ives, *p* 26. The Hottentots, Beschryv. i. 226. The Kamschadales, Steller, 271. 295. The nations on the Oronoko, i. 333. 335. Gumilla. *(Psalmanasar deceived Meiners for a time. T. C.)

* It will be necessary for the sake of some of my readers, to explain this allusion in my correspondent's paper. It relates to the method of making out the bill of costs of sheriffs and constables, who summon witnesses to court, and who are entitled to mileage only according to the nearest route. In the present year, 1814, also, an act passed the Legislature of Pennsylvania, allowing circular mileage to the President Judges of the court of Common

pay his laborious researches, though motives of secular interest were far, no doubt, from the Doctor's thoughts.

Blessings on the whole tribe of quotation-mongers, from Grotius to Burton, from Burton to Meiners, from Meiners to Magee,

Pleas, at the same rate as is allowed to witnesses who attend, or to constables who summon them. At the formation of the present constitution of this state in 1790, the salaries of the judges were settled at their present rate of $ 1600 a year (mileage lately allowed, amounting in this district to about forty dollars a year, only excepted.) At that time, the wages of the members of assembly, were two dollars a day: the members of assembly afterwards raised their own wages to three, and last session to four dollars a day. Had this rate of wages been appointed for the succeeding session, no person would have found much fault with it; but the implied contract between the representatives who voted themselves entitled to four dollars and took it, and their constituents at the time of election, was certainly for no more than three dollars. In common transactions, and among decent people in common life, this would have been considered *a fraud*. Had the wages been raised to eight dollars a day, in consideration that the session should break up before the frost breaks up, and continue but half the usual time, that half only of the usual number of laws should be passed, and half the hours only wasted in ignorant and noisy declamation, the public would indeed have been greatly the gainer.

From the year 1790 to this time, the business of the Judges has nearly doubled, the price of all the necessaries and comforts of life have doubled, and these men who have doubled their own wages within the same period, think it sufficient to add forty or fifty dollars a year in the degrading shape of post boy's pay, to the salaries of their Judges!

Hurlo thrumbo: Lord Chancellor Thurlow. The following dialogue actually took place at his Lordship's table. He was called out during dinner: when he returned, one of his guests said, "pray my Lord, if I may be so bold, "which of the cabinet ministers has disturbed your Lordship's devotions at "dinner?" "Cabinet ministers! I wish they were all at h— with the puppy Pitt at the head of them! No. It was the Archdeacon of St. Albans; he came to pester me for the Bishopric of St. David's, and talked me to death about his services to mother church. The canting rascal cares no more about the old b—h than I do: but he has fought faithfully against old gunpowder (Priestley), and he deserves the vacancy." Horsley led the pack so profitably, that it is the fashion for expectants to yelp in.

My correspondent evidently levels his remarks, not at the doctrine, but the method of proof, employed by Dr. Magee; otherwise, this part of the paper would be inadmissible. He may laugh if he pleases at Dr. Magee or myself, or any other of the laborious tribe of index-hunters: but I have nothing to do with theological opinions. I confess, I have always thought, that the only allowable way of establishing Christian doctrine, is by the Christian Scriptures; all other proofs, are at the best unnecessary. Is the tenet you advance plainly revealed in the Bible? If it be, the Bible is sufficient for a Christian: if it be not, can profane writers establish it? Do you distrust the authority of the scripture, that you seek elsewhere for support?

and from Magee to myself! Peace to the souls of them that be at rest, and prosperity to the living! Are not we the exclusive supporters of order and regular government? the very props and mainstays on which must rest the authority of every crowned head in Christendom? ay, and in Pagendom also? Are not we the only class of literary knight errants, who, despising all argument, pay passive obedience and non-resistance to all authority? How can the professors of law and physic—nay, how can the professors of divinity do without us? Is not our motto, *Stare decisis?* A bas les agitateurs? Down with the innovators? Away with the fallible pretensions of human wisdom, and the false lights of that ignis fatuus, human reason?

Moreover, although our storehouses are professedly repositories of stolen goods, yet we keep them for the benefit of the literary world. Although we do enable those who steal from us what we stole from others, to shine in borrowed plumes, like the classical essayists of London, who pillaged without mercy that amasser of other men's wealth Robert Burton—or like the Edinburgh reviewers, who dress themselves out in the cast-off cloaths of Jeremy Taylor, still we mainly contribute to the classical gaiety and literary finery of the day: and although the sober traveller may smile at the gaudy appearance of ancient frippery on modern linsey-woolsey, yet, *sunt quas arbusta juvant*, there are who do not dislike even the white, red and yellow trees before the door of a Dutch

Dr. Magee says to his reader, I can prove the doctrine of atonement from the word of God, and from M. de Pauw. Can you indeed? Then, for mercy's sake, spare us dear Doctor, the mortification of M. de Pauw! Will you drench us with ditch-water after Tokay?

> And thou Dalhousie the great God of war,
> Lieutenant Colonel to the Earl of Mar,

is sublimity itself in comparison to such an attempt. Moreover, if the practice, whose universality he labours to establish, be indeed, as he calls it, a horrid superstition, what aid can it afford to a doctrine of revelation? Is it possible he could be blind to the very obvious injury his opinions might receive from his quotations?

The truth is, that Dr. Magee's book is manifestly written, to serve, not the spiritual interest of the church, but the secular interest of Dr. Magee. Writer is introduced treading upon the heels of writer; quotation is heaped upon quotation; reference urges reference; criticism of sarcasm succeeds to criticism of contradiction; and authority is backed by authority, in endless and useless succession; meant indeed, to display the extent of the Professor's reading, but affording evidence still more decisive of the narrowness of his judgment. T. C.

house-wife, and the ever-green broad-brims and yew-tree tobacco pipes that adorn the garden of myn heer, her husband.

I have been led into this digression because not having been able to furnish you with a drawing of a kitchen fitted up to my mind, I sat down with a positive determination to shew the great importance of eating generally, and of good eating particularly, from the precepts and practices of divers great authors, who have incidentally or expressly treated this important subject. I meant to have rendered my position luce clarius, although by reflected light; and to have fortified and protected it by a seven fold shield of impenetrable authorities. But I have been induced to confine myself to narrower bounds, for reasons that I shall presently mention.

There are many passages, moreover, in classical and other books of importance, that can only be elucidated by a commentator who understands something of the history of eating. Thus, when we find how greatly people in general abhorred the practice of eating with unwashen hands, this can only be explained by shewing, that the Jews at that time, like other nations, had no knives, forks, or spoons, but eat with their fingers, as the Arabians to this day feed upon their cuscusoo. When our Lord desires the servants at the marriage of Cana in Galilee to bear unto the master of the feast, I apprehend this is a wrong translation, for the wine was under the controul not of the entertainer, but of the elected toast-master, the *arbiter bibendi: quem Venus sorte dixerat.* So when we read of the favourite Apostle who reclined in our Saviour's bosom, this can only be understood by a reference to the *Triclinia*, or couches, and the mode of reclining upon them: chairs being used at that time by females only; who afterward adopted the couches of men, when they began to throw aside the modesty of women.

Many questions of great importance in political economy also depend upon scientific and historical knowledge in eating. Thus, the introduction in England of napkins and silver forks to each plate, and of separate tumblers to each person at dinner, is a custom introduced even in families of rank in England within 50 years; and is by no means general even among the opulent of the middling classes to this day; while in France, the poorest person has his silver four-pronged fork, his napkin, and his separate glass tumbler. This arises from the mode of cookery peculiar to each nation. In France, they feed chiefly on soups, and on meats stewed or boiled till they are quite tender: hence, a knife is not so necessary an article in France as in England, but spoons and four-

pronged forks are essential, and cleanliness requires them to be of silver. Hence also, the French take up their food with their four-pronged fork in their right hand, while the left, holding a piece of bread, sweeps up the soft food upon the fork. Hence the necessity of napkins and separate tumblers, because a Frenchman's fingers are so often greasy at dinner time, while an Englishman has no occasion to soil his, in any degree.

These remarks will furnish a solution to the following questions.

1st. Why has the linen manufactory been cultivated in France to so much more perfection and so much greater an extent than in England?

2dly. What is the principal cause, why Great Britain is the greatest manufacturing nation in Europe?

3dly. Why is it that the system of paper credit, is more prevalent in England than the rest of Europe?

4thly. Why is the hardware of Great Britain, particularly the cutlery, superior to the same manufacture in other countries?

5thly. Why is the system of boxing more common in England than elsewhere, and the quarrels of the common people less murderous?

6thly. Why are the English better sailors than the French?

7thly. Why do the French excell in the manufacture of snuff?

8thly. Why are the French the best baker's in Europe?

9thly. In what particular has a French army an advantage over an English one?

10thly. Why is coin always plenty in France, and not in England?

11thly. Why are the English better book-binders than the French?

12thly. Why do the French, cæteris paribus, print books cheaper than the English?

These questions might be extended, but they are sufficient to shew the important bearings of my subject; and that no man can pretend to useful knowledge of almost any kind, unless he have knowledge in the science of eating also. And now to their solution.

1st. Why has the linen manufacture been cultivated in France more extensively than in England? Because from their mode of eating, dependant on their mode of cooking, there is a much greater demand for, and consumption of napkins and table cloths.

Their mode of washing linen by means of beaters also, greatly contributes to its consumption.

2dly. Why is Great Britain the principal manufacturing nation in Europe? Because their taste in eating has driven them to the necessity of using stone coal for fuel; and of perfecting their iron manufactory, on which all other manufactures depend.

The people on the continent of Europe, prefer small dishes, soups, and stews, which can be cheaply and conveniently cooked with charcoal. The English have from time immemorial been attached to large joints, particularly of roast meat. This has driven them for cheapness to the use of coal, the cheapest of all fuel, and the very ground work and basis of all manufacture.

Their large joints require knives and forks, of large dimensions, and of good temper: hence, as an article in perpetual use three or four times a day, neatness, goodness, and cheapness early found their way into this branch of the iron manufacture, and gradually extended itself to every other branch.

3dly. Why is it that the system of paper credit is more prevalent in England than the rest of Europe?

Paper money will be first used, and more extensively used, in those places where gold and silver are comparatively scarce. It will be long before it comes into play, in a country where precious metals are abundant. The precious metals will be abundant in those countries, where they are in the greatest demand and in general use for domestic purposes, and the common wants of life.

Owing to the English taste in eating, and their gross method of cooking, steel knives and forks have banished silver. For the latter metal is not fit to cut up a buttock of beef, or a sirloin. While in France, the use of soups, stewed meats, and salads, have rendered a silver four-pronged fork and a spoon necessaries of life to every man, woman, and child in the country. This has extended the use of silver to evey other article of the table: thus, plates, dishes, and tureens—plateaux, waiters, and candlesticks, there, are silver. In England, the neatness and cheapness of the pottery manufacture, especially since it has been directed by the taste and science of Bentley and Wedgewood, has superceded, even among the English nobility, the necessity of silver services. Then again, the system of plated goods in England, dependant on the general state of their manufactories, as controuled by their collieries, has banished solid silver from their houses: to which a very inefficient and defective police has greatly contributed. Hence, in France the precious metals, particularly silver, have al-

ways been and still are in great abundance; in England the reverse has been the case. Hence real money, gold and silver, to this day, is the only circulating medium of the former nation: while in England, the precious metals are nearly banished, and the iron age prevails. The hoarding of the precious metals during the reign of Robespierre and revolutionary principles, and the issue of paper money in France at that day, hardly forms an exception to the general remark.

Hence, perhaps, if the females of England had been better skilled in French cookery, the bank of England need not have stopt payment.

4thly. Why is the hardware, particularly the cutlery, of England, so much superior to the same manufacture in other countries?

Because it is evident, that the gros morceaux, that load the English tables, require this superiority: and the daily use of cutlery at meals, instead of silver, naturally produces more demand, more competition and more skill.

5thly. Why is the system of boxing more common in England than elsewhere, and the quarrels of the common people less murderous?

This is owing to the fashion of feeding. In England, the knives do not shut. The meat requires them to be too large for the pocket: those who find you meat, find also knives to cut it with. On the continent, every man carries in his pocket his own couteau. The persons who find meat, find forks only. Hence abroad, a vulgar, quarrelsome brute, has always his knife—his snickersee, in his pocket to resort to; an Englishman has nothing to betake himself to but his fists. Dr. Bardsley, of Manchester, has written a very learned, a very elegant, a very ingenious essay in favour of boxing, which some day or other I will republish.

6thly. Why are the English better sailors than the French?

The English are better accustomed to relish and digest the hard and solid provisions, on which a sailor must subsist. This is not the only, but it may reasonably be regarded as one cause.

7thly. Why do the French excel in their manufacture of Snuff?

Because it is necessary to suppress and obtund the odour of garlic, rocambole and shalot in their houses and their streets, arising from its predominance in their cookery. Does their more extensive use of perfumes arise in any degree from the same cause?

The French also appear to me better botanists and gardeners than the English, owing to the greater variety of vegetables employed for culinary purposes: by the way, the Abbe Correa, informs me that the purslain, phytolacca oleracea, a very good culinary vegetable, and commonly used in France, is to be found in all the streets of Lancaster, Pennsylvania, and the amaranthus viridis (or else blitum, *Careless)* is common at Carlisle. The dandelion, the sow thistle, the lambs-quarters, the poke, the sorrel might also be used in places where gardens are scarce with us: that is every where in this state. I greatly regret the want of truffles, morills, and garden mushrooms in this country, where for the most part there is no taste but for tables so crowded as to sate the appetite by the very sight of the dinner; and where the delicaces of an European entertainment are little known. But I do not feel inclined to speak favourably of the plateau; it hides too much of the dinner, and is an obstacle to mutual assistance at the table, which forms in my opinion one of the pleasures of a feast instead of being a trouble: as it did among the Greeks and Romans. It is an interchange of civilities and good offices, and prolongs the repast. The drinking of healths *at* dinner, is an abomination: it is almost as bad as segars after. People who have dismissed their plate, and are at leisure, may slightly bow to each other, but to disturb a man while he is eating, and compel him to quit the plate he is enjoying, to drink when he does not wish it, is very impolite, very troublesome, and very unpleasant.

8thly. Why are the French the best bakers in Europe?

They eat more bread. The fork occupies exclusively the Englishman's left hand, the bread employs the left hand of the Frenchman, who is by no means gauche on this occasion.

9thly. In what particular has a French army an advantage over an English one?

The French are all cooks: they are better cooks: they are more frugal and saving cooks: they can manufacture an excellent meal, out of what an Englishman would waste, or throw away. In French cookery, nothing need be lost: in English cookery a fourth of the food is wasted in the cooking, or thrown away afterward from bad cooking.

10thly. Why is coin always plenty in France, and not in England?

Because their kitchens, and their sideboards require a much greater supply of the precious metals than the English. Hence the precious metals, silver especially, in use for every domestic

purpose, abound there. In England their use is *comparatively* confined to coin.

11thly. Why are the English book-binders better than the French?

The English consume more meat, or rather waste more meat than the French. They kill more calves and sheep in proportion. Hence the materials of binding are cheaper. Also, because England is superior as a grazing country.

12thly. Why do the French print books cheaper? or rather sell them cheaper?

Because the use and wear and tear of linen is much greater in France than in England; particularly at dinner. In the latter country, they use much more cotton and woollen. Our napkins and doyleys are generally, and our table cloths frequently of cotton, in America, I believe, as well as in England.

I promised to assign my reasons for not dwelling upon authorities in support of the importance of eating and drinking and the science which puts them under the guidance of health and prudence, as well as pleasure. In truth I found the materials so accumulated on my hands, that I am obliged to give up my design in compassion to my readers. After turning over Horace and Juvenal,* and the lives of Vetellius and Helio (or Ela) gabulus,

* In looking through Horace and Juvenal, I find the following articles introduced at a Roman table.

Gobeo the Gudgeon, came in the first course.

Muræna: the Lamprey, served up with Shrimp sauce. The Lamprey is not uncommon in Philadelphia, and is excellent, though neglected.

Anguilla: the Eel: a fish not much thought of: but if Elagabalus who first introduced the oyster pie, had tried an eel-pie, well seasoned, he would have found it eatable.

Rhombus: the Turbot: the first of all fish: certainly superior to the Sheep's head; when served up with lobster or shrimp sauce after the manner of the ancients. It is eaten, I understand, at Boston; which I shall note in my Gastronomic chart. I am not well acquainted with John Dory. Next to this, is

Solea: the Sole, not common here.

Passer: the Fluke or Flounder.

Mullus: the Barbel: concerning the Barbel, and the observations thereon of Plutarch and Gesner and Gasius, see Hawkin's Complete Angler, one of the most entertaining books in the language.

Silurus: the Shad. The salted Shad are peculiar to the middle states of America. I have eaten Shad in England, but not good. They do not understand relishes in England.

Scarus, the Sear.

Accipenser, the Sturgeon: the pickled Roe is the Cavear.

by Suetonius and Lampridius, I found I had to wade through the Deipnosophista of Athenæus with the commentaries of Casaubon and others, and the natural history (such as remains to us) of Aristotle, and more especially of Pliny the elder, and Galen. That I

Lupus, the Pike: a young Pike is a Jack.
Lagois, is a fish with which I am unacquainted.
Peloris, I cannot assign a modern name to.
Mytilus, a Limpen.
Murex, a Muscle: perhaps a Clam.
Cocklea, *Conchylia*, Cockles.
Echinus, a Craw fish.
Perna, a Prawn.
Squilla, the Shrimp.
Ostrea, an Oyster.
Pecten, a scollop Oyster. A Clam?

Such are the fishes mentioned in these authors: but there were many of which they take no notice.

I do not find that Horace or Juvenal mention any of the following fish, noticed by others, chiefly Pliny and Galen.

Cancer: *Gammarum*, the Crab: *Conger*, the Conger-eel: *Cyprinus*, the Carp: *Thynnus*, the Tunny: *Raia*, the Ray or Skate: *Raia clavata*, the Thornback: *Pecca*, the Pearch: *Erithinon*, *Rubellio*, the Roach: *Scomber*, the Mackarel, which ought to be far more frequent at our tables as a fresh fish, than it is. *Hilecula*, the Pilchard, the Sardinia, or the Anchovy, for I am in doubt about this. *Aurata*, the Gold fish; not the modern Chinese fish, I presume, that are now kept for ornament, but the el Dorado, so common at sea. *Xiphias*, the Sword fish. *Asellus*, the Cod. *Mustela*, *Galexia*, the Eelpout. *Glaucus*, I suspect this to be either the streaked bass, or Rock, or else the Mackarel. *Garum*, I am in doubt about this also, some think it the Mackarel, I think it was a Lobster or a Crab; it was a fish used as a pickled fish, of which the pickle was in great repute. Of the Crab or Lobster kind, I reckon the *Mæa*, and the *Echinus*. The *Lucius*, I translate a Haddock; though on the authority of Ausonius, it is usually considered a Pike. Hugo de Friedwald, supports me in this; but it is not clear. I must give up for the present the *Acus*, the *Smaris*, the *Mæna*, the *Sudis* or *Sphyræna*, the *Mollua* (soft shelled crab?) the *Lampetia*, the *Sturio*, the *Sargus* or *Melamurus*, the *Latus* (Flounder?) the *Locusta*, *Astacus* (Lobster?) the *Trachinus*, the *Cornua* or *Orphon*, the *Lamia*, the *Libella*, the *Aquila*, the *Corvus* or *Coracinus*, the *Pagrus* or *Pagyrus*, the *Clypea* or *Alosa*, with many others whereof mention is to be found in the thirty-second book of Pliny, and in Galen. It is greatly to be wished that five good scholars, including a botanist, a naturalist, and a mineralogist, would sit down to the translation of Pliny's natural history, and add notes to it. I hardly know any single man, or indeed any two men competent to the task. I do not find that the ancients knew any thing of our Trout, Salmon, or Sea Turtle. I am not clear about the Tarrapin, and the Land Turtle.

had then, to give some account of my worthy and most renowned predecessors in culinary science among the ancients, Mithæcus, who published the much-esteemed Sicilian cookery—Numenius of Heraclea—Hegeemon of Tharos—Philoxenes of Leucadia—Actides of Chio—Tyndarides of Sicyon—Thimbron of Athens—and Archistratus who went upon his Gastronomic travels, as Dr. Burney travelled to learn the modern state of music—Arthur Young that of agriculture—Ferber and Faujas that of mineralogy—Linnæus and his scholars, down to Michaud, that of botany, and so forth.

I had then to consult and analyse the cookery of Cælius Apicius, with the commentaries of Humelbergius, Caspar Barthius, Reinesius, Vander Linden, and Lister, a book of which I propose, God willing, to give a good account, the rest notwithstanding. Then had I to dive into Aldrovandus and Gesnerus *de piscibus*, among the moderns: and to dig among the ruins of the 9th folio of Gronovius for Castellanus de *carnium esu:* a dissertatiuncula de *callido potu* (which goes in Carlisle by the names of stewed whiskey, hot toddy, and potassium): and Hieronymus Mercurialis, *de potionibus ac eduliis antiquorum:* and Baccius, *de conviviis* (that is the fishing and beefstake parties) *antiquorum:* to the same pur-

Horace and Juvenal mention, *Jus*, sauce, as the same French word means: *Assis* broiled or roasted fish: roasted on a board as we do shad: also roasted meat. *Garum, Alec, Muria*, fish pickle. Garum was made from the Mackarel, as is supposed; I think from the Crab. Alec from the roe or melt of fish; the melt of our Shad, boiled for barely one minute in vinegar diluted with one third water, well spiced, is much superior to any pickled oyster. Muria, is the pickle from sea fish.

The same authors mention *Sumen*, the breast of a sow, not the udder as I think: the Hare, *Lepus:* the Boar, *Aper:* the *Pygargus*, a Roebuck? *Scythicæ volucres*, game of all kinds: *Afra*, the Turkey: *Pavo*, the Peacock, which when young is a good bird: *Turdus*, the Thrush: *Gruis*, the Crane: *Anser*, the Goose: *Merula*, the Merle: *Palumba*, the wood Pidgeon.

We learn from these authors that the ancients employed *Structor* a carver by profession; that they fined their wine with Pidgeon's eggs; that they often mixed Hymettian honey, like blockheads, even with their Falernian. They used *Mulsum* mead, as a beverage. Among their relishes (probably at the Commessatio after supper) they dipt their bread in Garum, Alec, and Muria; they had also *Hillæ*, sausages. These authors mention as vegetables in use, *Rapula*, the Rape; *Radix*, the Radish; *Lactuca*, the Lettuce; *Siser*, the Skirret; *Porrum*, the Leek. Having cast my eye with some care over Horace and Juvenal for the purpose of this essay, I thought the preceding enumeration of articles might be deemed curious at least, if of no use.

pose nearly, also is the treatise of Laurentius, *de conviviis veterum:* nor could I omit the learned remarks of Hugo Freidwall, *de sanitate tuenda*, who treats much of ancient food: Pignorius, *de servis*, or waiters at table, wherein of the sectores or carvers, very necessary to be introduced in our day; wherein Tripherius read lectures, having various dishes made in wood, dissected according to the best rules of carving: Musonii philosophi, *de luxu Græcorum, in quo de helluonibus, de bibacibus, &c.* concerning which, unless this philosopher were tolerably well skilled in the practice, he was not well qualified to write; as Harry Fielding shews at length in his history of Tom Jones. Then, had I to run over the pages of Laurentius, *de Prandio et Cæna veterum;* the blockhead thinking, I suppose, the Jentaculum, and the Commessatio, or relish after supper, of no consequence.

After this, I had to consult Meibomius, *de Cerevisiis veterum*, and Possidonius in Strabo on the smoking of cegars among the Mysian Scythæ. Strab. L. 7. ed. Casaub. Smoking and ale-drinking being naturally companions.

Nor should I have omitted the Hylophagi; or the Spermatophagi noticed by Diodorus Siculus, L. 3. ch. 7. which would of course draw after it, an investigation of the Chinese spermatology introduced to our acquaintance by Mr. Barrow, and which Sir George Staunton has strangely omitted: nor do I find that Lord Macartney himself had carefully studied it.

Nor could I have omitted the strange taste of the

"Anthropophagi who each other ate."*

Then had I to peruse the collections of Potter and Du Bos, and Kennet, and Adams: and to relieve their dull and dry details,

* The following nations have been accused of being Anthropophagi, on the authorities annexed; but I do not give full credit to all the charges.

The inhabitants of the isles of Noussa Laout near Amboyna. *Valentyn.*

The inhabitants of several islands near the isle of St. Mary. *Adams's Voyages*, 1598.

The islanders of Cayenne. *Froger's Voyages.*

The Carabees of Guadaloupe. *Voyage of Columbus.*

The tribes on the banks of the Yupara. *Condamine.* 1743.

Other Indians on the borders of the river Amazon. *Acuna and Artieda.*

Those on La Plata. *History of Paraguay.*

The savages of Brazil. *Laet Knivet.* The Mexicans and Peruvians. *Gomara. Voyage of Pizarro.*

The Scythians—Budian Scythians. *Herodotus.* The ancient Galatians. *Boemus.*

with the travels of Anacharsis and Antenor. After this I had to examine the ill natured account of an imitated ancient dinner given to us (with the relish indeed of exquisite attic salt) by the learned Dr. Smelfungus in Peregrine Pickle, to the great mortification of Akenside the poet.

When I came to consider all this, and to reflect seriously

Quid valeant humeri quid ferre recusant.

I began to despair of my undertaking, and, as the common saying is, to draw in my horns.

We have two tolerably detailed accounts of ancient dinners, that of Nasidienus by Horace, and Trimalchio by Petronius: we have two accounts excellent in their way, of the ancient dinners (or rather suppers, as they were called, though they generally began about three in the afternoon) by the Abbe Barthelemy, in the travels of Anacharsis, and by Smollet in Peregrine Pickle. To copy Horace, or Smollet, or Barthelemy, would be unpardonable: to every modern reader they are, or ought to be, familiar. But Petronius falls into few hands, nor is he an easy though an elegant author. If therefore you will accept a translation of Trimalchio's feast, and an analysis of Apicius Cælius, with some receipts in cookery out of that author, they shall be at your service.

EPICURI DE GREGE PORCUS.

The Samoydes—as their name indicates in their own language.

The Tartars of Kardan. *Voyage of Marco, polo.*

The negroes of Sierra Leona; of the Gold coast; and of the Ivory coast. *Barbot. Loyer, and Villaut.*

The negroes on the Gambia. *Le Brue.* Those of Juida. *Philips.*

Those of Dahomai, the Acquas, and Zamazones. *Snellgrave.*

The Jaggas. *Battel's Voyage.* The Mumbos of Monomatapa. *Faria*, vol. 2.

Lately the New Zealanders, and some inhabitants of the Southern isles, have been accused of the same practice. See Edinb. Ann. Reg. 1809.

See Coutumes des differens Peuples, Tom. p. 1 to 15.

NOTICES.

I HAVE received from Mr. Thomas W. Ruble, of Kentucky, notice of a steam engine of his invention, where the water of the boiler surrounds the cylinder. I suspect that although this arrangement has its conveniences, it is not new. I have heard of it in use in England.

Want of a plate prevents me from inserting Professor Cutbush's paper on Mr. Cloud's method of making seltzer water. It will appear in the next Emporium.

My publishers write to me, that complaints are made of my papers on manufactures being too long. They ask when I begin the subject of dying.

My design in this work is to make it the best publication *any where* extant, as a body of information on MANUFACTURES. I do not profess, I will not condescend to skim over my subjects with the appearance of knowledge, but with useless or shallow information, where good can be obtained. I dedicate at least one third of this work, greatly against my own inclination, to miscellaneous and comparatively trifling papers. About these I care little. But I say to those who complain,

Shew me in any European language, the same amount of real information, on *Iron*, *Steel*, *Steam Engines*, *Copper*, and *Lead* in the same brief compass as I have given it.

Shew me, any single European publication on either of these subjects, that contains any thing approaching to the same quantity of important knowledge, which the Emporium has furnished.

I say to those who complain, that *they cannot shew this.* I know it.

Under these circumstances, if the work be such as I represent it (and if it be not, let those who can shew otherwise)—if it really do contain a condensed body of manufacturing information, not to be found but by hunting up publications scarce, voluminous, and dear, and not then—what reason have I to change my plan, or to suspect that such a work will not be reasonably supported? If it be not, it is well: I will give it up: but I will not swerve from my own ideas of propriety in conducting it.

As to dyeing, I suppose there may be twenty or thirty subscribers anxious for such an article, and caring nothing about any other part of the work: I believe the articles I have published, of far more importance; but it shall have its turn. T. C.